Remote Patient Monitoring

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Declaration

I declare that the work described in this dissertation is, except where otherwise stated, entirely my own work, and has not been submitted as an exercise for a degree at this or any other university.

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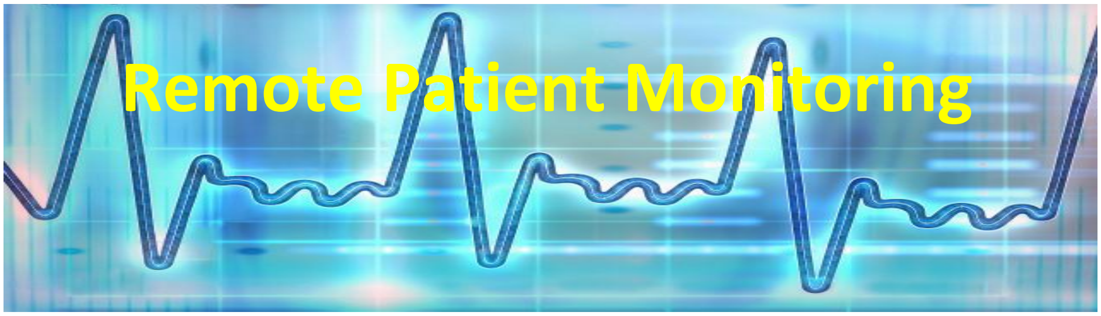
Remote Patient Monitoring

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I would also like to make a special thanks to Mr. Lei Lei from Apple who assisted me with my Iphone app prototype and to Dr Joseph Cazzigi would kindly offered his support and results from a similar study.

Contents

Summary

The research method I have chosen to use is the Qualitative Method. I found this method was more suited for my research as Remote Patient Monitoring field is still in the early stages especially in Ireland. I find with the Qualitative research method the data is clearer and more readable as the concepts and findings are articulated in words, it allows me to use a more flexible approach.
I have included a literature review to show what others have written on this topic before me, it will allowed me to narrow other authors work and make it relevant and concise in relation to my topic.
Two qualitative methods I will use in my research are Case Studies and Grounded research.

Findings

Globally, healthcare is heavily burdened with massive and growing expense that is crippling the healthcare system. This has been well documented by reporters, analysts and researchers alike. Innovative solutions are desperately needed to control these costs, solutions such as Remote Patient Monitoring (RPM).

It is essential that we move towards keeping people out of hospitals where possible, and exploit available and emerging technologies to ensure that people can be managed effectively from within their daily environment.

Technologies already in use today by populations can enable clinicians to remotely monitor a patient outside of a hospital environment preventing worsening conditions, emergency care, hospitalisation and other costs like nursing homes.

Aging baby boomers are considered as the major drivers of a rapid movement toward RPM. By constantly 'being connected,' patients are more involved in the decision-making process regarding their treatment and overall health management. Another major driving force for physicians, hospitals and home health organisations to focus on monitoring their patients is cost savings (Vignet 2009).[1]

The finding in this research show that healthcare costs could be better contained while at the same time patient health could be improved if the healthcare community could take a more proactive approach to allocating medical resources, while patients themselves can be more engaged in managing their own care.

This research shows that healthcare needs to move toward a new vision of 'connected health' to deal with the future demands of healthcare which will inevitably create relationships among healthcare providers to enable delivery of safe, affordable, accessible health services.

Case studies in this research show that if patient suffering from chronic conditions agreed to have their clinician monitor them remotely via mobile wireless applications, huge healthcare cost saving would be seen in emergency care, hospitalisation and nursing home costs.   Potentially patients would also have a an improved quality of life with less visits to hospitals and clinicians would have more clinical data to proactively help prevent worsening conditions.

The growth has been slow primarily because of rapid changes in technology with no standardisation and lack of awareness about health and health monitoring solutions. Another reason for slow growth globally is due to lack of reimbursement for clinicians – clinicians have more data and patients to analyse, extra work but no extra money.

This research shows that Remote Patient Monitoring is bound to grow, given the cost effectiveness of the solution and growing health need. There is a need to create awareness about Chronic Diseases among patients, their families, and general public and even doctors for the seriousness of the chronic diseases and spread education about Mobile Monitoring being highly cost effective and reliable solution for monitoring Chronic Disease. The challenge, however, is to translate the successful pilot experiences into financially sustainable, widely adopted care processes.

Abbreviations

AHRQ	Agency for Healthcare Research and Quality
AIMDD	Active Implantable Medical Device Directive
ANA	American Nurse Association
BSI	British Standards
CHF	Chronic Heart Failure
DTMF	Dual-tone multi-frequency
EHR	Electronic Health Record
GDP	Gross Product
GP	General Practitioner
IAEM	Irish Association for Emergency Medicine
ICU	Intensive Care Unit
IQR	Interquartile range
LOS	Length Of Stay
MDD	Medical Device Directive
NFC	Near Field communication
NT	Nurse Telephone
NYHA	New York Heart Association class
PCP	Primary Care Providers
PSTN	Public switched telephone network
RPM	Remote patient monitoring
UC	Usual Care
UHN	University Health Network
USDHHS	United States Department of Health and Human Services
WHO	World Health Organisation

Chapter 1 – Introduction

Remote Patient Monitoring

Research Question

Can Remote Patient Monitoring ease the massive burden on current healthcare system? Is it a viable solution to deal with ageing baby boomers crisis? Can mobile phone technology be used as the service delivery platform for Remote Patient Monitoring?

Introduction

Globally, healthcare is heavily burdened with massive and growing expenses. This has been well documented by reporters, analysts and researchers alike. Innovative solutions are desperately needed to control these costs. Technologies already in use today by populations can enable clinicians to remotely monitor a patient prevent worsening conditions, emergency care, hospitalisation and other costs like nursing homes.

Vignet report Mobile enabling Connected Health Industry for the Continua Alliance states (2009), states that in 2009 the US health spending was expected to reach over 18% of the GDP, more than $2.5 trillion, and it is expected to reach $4.4 trillion by 2018 —more than double the spending in 2007. Vignet also report that in the UK the NHS costs are projected to rise from $50 billion in 1998 to $224 billion by 2011.[2] As shown in 'Telecare for an Ageing Population' report (Greaney, Blair, Courtney, Maher, 2008) healthcare expenditure in Ireland has increased dramatically from €3.6 billion in 1997 to the budget allocation of €16.2 billion in 2008.[3]

With its privacy concerns and data-intensive nature healthcare IT is an important issue for both governments and private organisations. It also has the potential to improve health service delivery for those who consume health services the most.

Healthcare costs could be better contained while at the same time patient health could be improved if the healthcare community could take a more proactive approach to allocating medical resources, while patients themselves can be more engaged in managing their own care.

As the cost of technology and telecommunications continues to drop, it appears that the healthcare industry is on the verge of a revolution by utilising Internet and Wireless technologies to address key healthcare challenges such as health care at home, patient monitoring, and medical record management with clinical decision support.

Standards based on an interoperable health system is emerging (e.g. from Continua Alliance) that empowers people and organisations to better manage their health through collection of data from multiple wireless devices and applications into EHRs. This improves healthcare services across the board regardless of geographic location, race, age, gender or disability Vignet (2009).[4]

Chapter 2 - Global Healthcare Analysis

Introduction

Before researching a topic the first question I needed to ask myself what is the purpose of the research. Research should be used improve current environments to improve mankind in all aspects of the way in which we live and interact with the world.

Before researching a selected topic/area I feel it is important to identify the reason for the research, the problems which the research could help to resolve. I have included this section to highlight the current issues and problem domains that are gradually crippling the healthcare industry.
These are as follows:

- Increase in Population
- Ageing population
- Increase in Chronic Illness
- Shortage Of Clinicians
- Hospital Bed Shortage
- Rising Healthcare Costs

Increase in Population

Statistics from the World Bank (21/05/2010) indicate that the world's population has doubled in the last 40 years. The increase in population will inevitably increase the demand on the healthcare systems. Below in the table you can see the world population has neared doubled in the last 40 years.

World

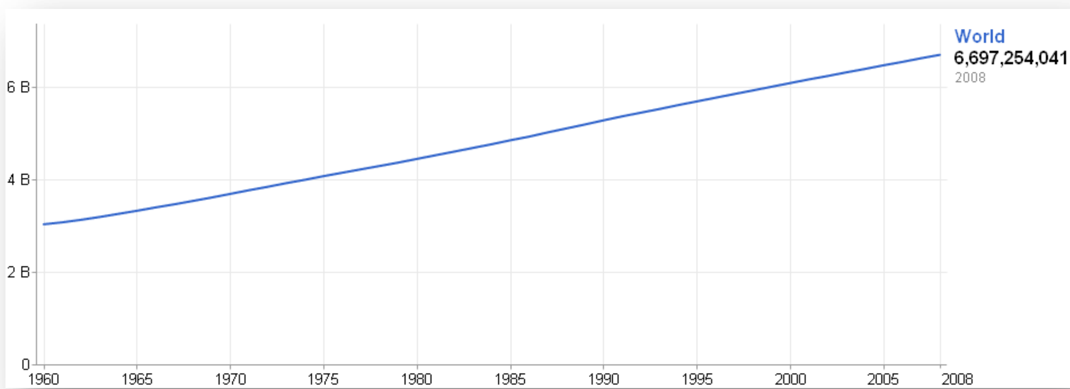


Figure 1 [5]http://data.worldbank.org/data-catalog/world-development-indicators?cid=GPD_WDI

Ireland

These statists are not confined to a single country as all countries globally have seen a steady increase in their population. [6]

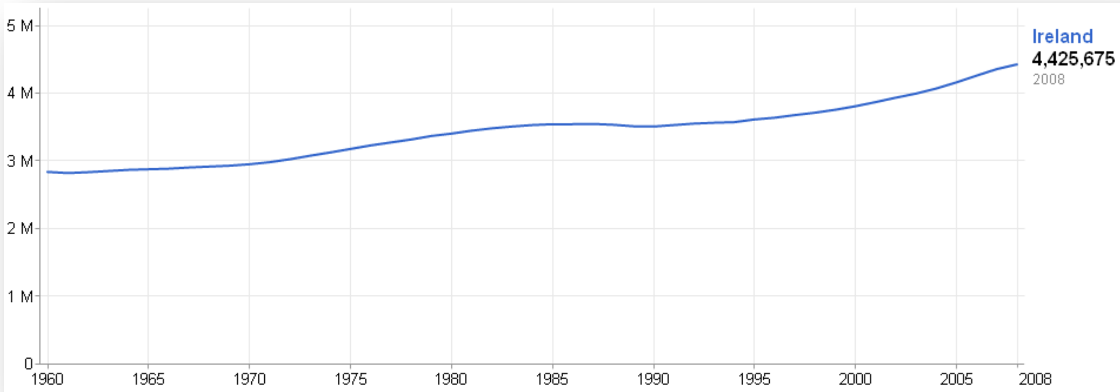


Figure 2 http://data.worldbank.org/data-catalog/world-development-indicators?cid=GPD_WDI

Ageing population

Due to advances in public health and medicine, people are living longer than ever before. As shown in *Figure 3*, the number of persons 60 and older in 2000 was 600 million (10% of total population of 6 billion). World Health Organisation (2008) estimate that this figure will double to 1.2 billion by 2025 (15% of total estimated population of 8 billion) and will have reached 1.9 billion by 2050 (19% of estimated population of 10 billion).[7]

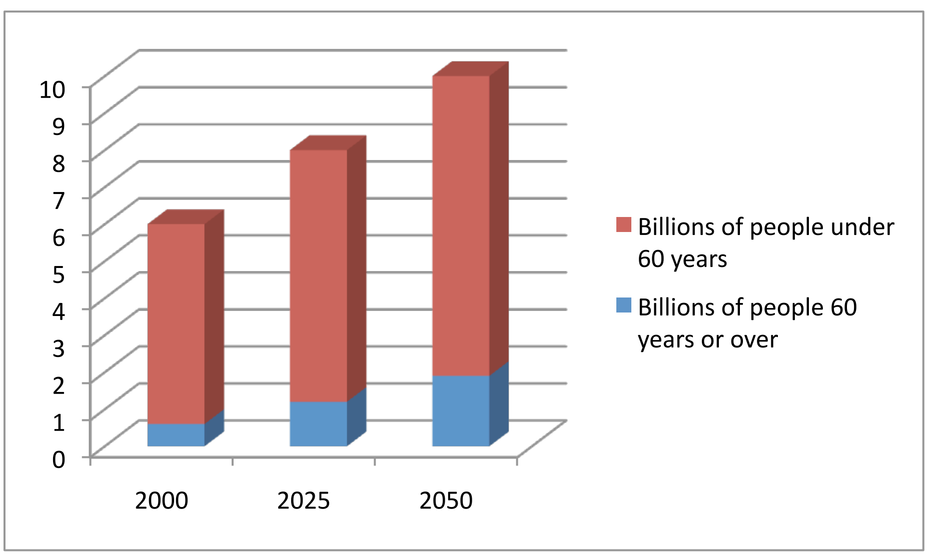
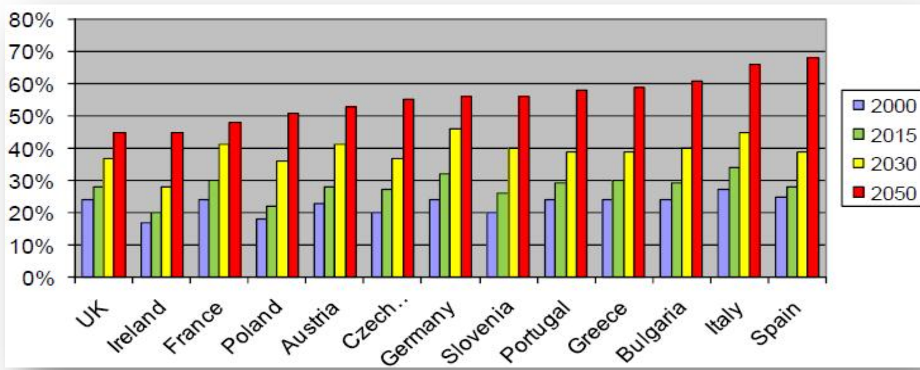


Figure 3: Global population in billions showing proportion of people 60 years or older in 2000 and projected for 2025 and 2050

Figure 4: Bar graph below shows a graphical representation of the percentage of elderly population in the year 2000 and the expected population in 2015, 2030 and 2050. In most European countries, the elderly populations will double or even triple in size.



[8]

Figure 4 (Fitzgerald 2009)

While some of this rise can be attributable to increases in the quality of healthcare in developing countries, this trend is also evident in the developed world.

The very old (>80 years) are the fastest growing population group. Schäfer (2008) of the Statistical Office of the European Communities state that older people are more likely to suffer multiple health conditions, chronic physical diseases and mobility limitation, often with concurrent mental and cognitive disorders, all of which requiring constant attention and care. [9] As the numbers of pensioners increases relative the number of taxpayers there will be less funding available to pick up this growing health bill.

The majority of elderly people wish to remain independent and some are likely to take the opportunity to migrate for long periods of time to the milder climates of southern Europe (King R, Warnes AM, Williams 1998)[10], away from regular contact with their usual physicians. And even for those elderly people who choose to remain at home, the distance between them and their physicians can become an issue (Elkan R, Kendrick 2004).[11]

Frost and Sullivan (2008) envisage that the aging population, especially regarding care of the critically ill, will have a tremendous effect on healthcare. Considering that more than half of all ICU stays are incurred by patients older than 65 years.[12]

Increase in Chronic Illness

Patients with chronic disease take up large volumes of healthcare resources as the patient needs constant monitoring and care.

Global Scenario

The World Data Bank show that over 860 million people worldwide have long-term conditions (diabetes, cardiovascular, respiratory, mental, bone and joint) and this figure is set to increase due to rises in the number of people with obesity (it is estimated that one billion adults internationally are overweight).[13] Statistics from the World Health Organisation website (Nov 2009) show:

- Over 600 million people worldwide have chronic diseases.
- Chronic diseases are responsible for 60% of all deaths worldwide.
- 80% of chronic disease deaths occur in low and middle-income countries.
- Almost half of chronic disease deaths occur in people under the age of 70.
- More than 1 billion people in the world are overweight, and at least 300 million of these are clinically obese. Without action, more than 1.5 billion people are expected to be overweight by 2015.
- Prevalence of diabetes in the developing world will increase by 48% by year 2005, which will equate to an actual number of 170% in the number of diabetes sufferers.
- By 2025, over 75% of diabetes cases will be in the developing world. [14]

US

Mc Daid, editor of Eurohealth Volume 15 (2009), states that chronic diseases account for seven out of ten deaths in the United States, and consume 75 cents of every dollar spent on health care.[15]

Europe

Europe as a continent is faced with an aging population that is also experiencing increasing numbers and intensity of chronic diseases.

Frost & Sullivan (2008) have estimated that:

- 50 per cent of the hospital bed occupancy in European hospitals is by patients suffering from chronic illnesses, such as diabetes and chronic obstructive pulmonary disease (COPD)
- during the last decade, COPD has increased in women by 30 per cent
- 70 per cent of healthcare expenditure is already being spent on coping with chronic conditions in Europe.[16]

This year the Continua Alliance claim that he care of people with long-term conditions consumes 75-85% of healthcare spending, an increase of 5-15% from Frost & O'Sullivan figures of 2008 (Continua Alliance 2010).[17]

UK

In the UK the number of people with long-term conditions is also steadily increasing. Figure 5 shows the projected rise in expenditure in the UK in long-term condition management unless action is taken.

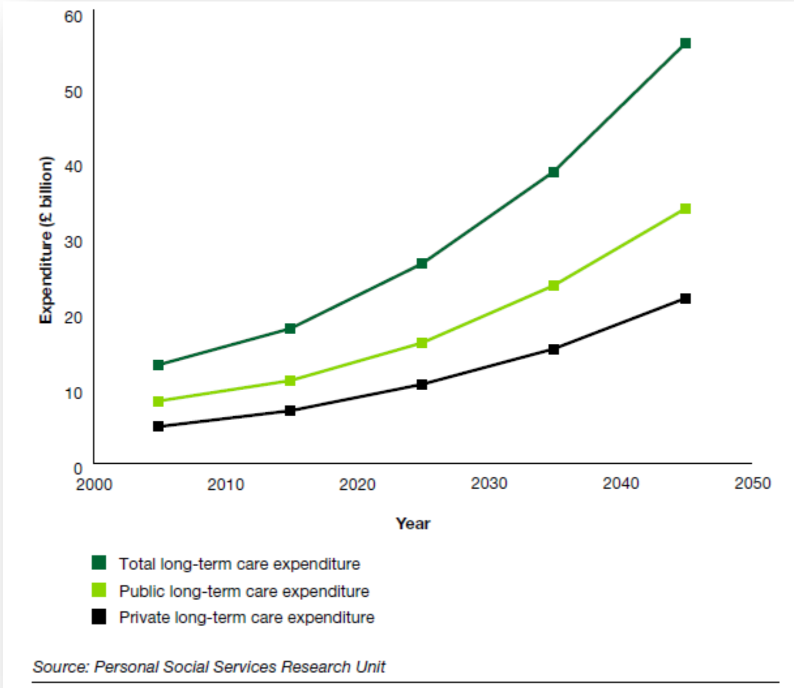


Figure 5 (UK Audit Commission Local Government Report 2010) [18]

Shortage Of Clinicians

The global shortage in health workforce

Health workers are the cornerstone and drivers of health systems. In 2006, the World Health Organisation showed that there is a massive global shortage of health workers, more than 59 million health workers were working worldwide, 4.3 million short of the total needed.[19] In recent years, there are concerns about growing shortages of health professionals even in the most developed of nations (Dumont & Zurn 2007). [20]

Reasons for shortage in health workforce include:

- Underproduction of clinicians (NHS 2002)[21]
- Human resource maldistribution and health workforce migration for better working conditions (Chen, Evans, Anand, Boufford, Brown, Chowdhury 2004)[22]

- Health hazard and violence against clinicians resulting in them quitting their jobs (WHO 2006)[23]
- Clinicians, especially young doctors, are working fewer hours and pacing greater emphasis on personal time (Jovic, Wallace, Lemaire 2006) [24]
- Substantial number of clinicians leaving the health workforce because of poor health, death and retirement(WHO 2006)[25]

In OECD countries, workforce ageing will decrease the supply of physicians as the "baby boom" generation of health workers reaches retirement age (Dumont & Zurn 2007).[26] For example, in UK, the NHS (2000) claim the shortage of qualified medical staff is crippling the National Health Service.[27]
The RTE news (2010) reported that the shortages of junior doctors in Ireland are resulting in a number of hospitals having to close their emergency departments or limit their opening hours, Dundalk being the latest casualty in June 2010.[28] The Irish Association for Emergency Medicine (2010), which represents consultants working in emergency medicine, said some hospitals have severe difficulties recruiting non-consultant hospital doctors, to staff their emergency units. Irish doctors are apparently going abroad for better work and training conditions and also the fact that it was now more difficult for overseas doctors to get registered here. [29]
In the US, the USDHHS are projecting a nationwide shortage of almost 100,000 physicians, as many as one million nurses, and 250,000 public health professionals by 2020.[30] Within the next 10–15 years most of the nurse workforce will be retiring, just when baby boomers will also retire and become eligible for Medicare (Buerhaus, Staiger, Auerbach, 2000). [31] Unruh and Fottler(2005) estimate that by 2020 there will be a 20% shortage of nurses.[32]

Hospital Bed Shortage

Globally, there is shortage of patient beds due to growing demand from the worldwide aging population, which is outpacing supply of beds in medical facilities. Majority of healthcare facilities, of late, are reducing bed capacity to minimize cost, and to promote advanced, short-stay surgical methods (http://www.officialwire.com/main.php?action=posted_news&rid=126010 2010).[33]

HSE Acute Hospital Bed Utilization

PA Consulting Group (2007) and Balance of Care Group (BOC) were commissioned to undertake a review of acute hospital bed utilisation in those hospitals with an Emergency Department (ED) throughout Ireland.

A total of 3,035 patients were randomly sampled out of a patient population of 8,322 (36%). The study shows that 13% of hospital admissions and 39% of hospital days were considered to be inappropriate based on the AEP criteria.[34]

Rising Healthcare Costs

Globally

The Organization for Economic Cooperation and Development released historical statistics on health care (07/2009), showing that health expenditures have risen drastically across the industrialized world.

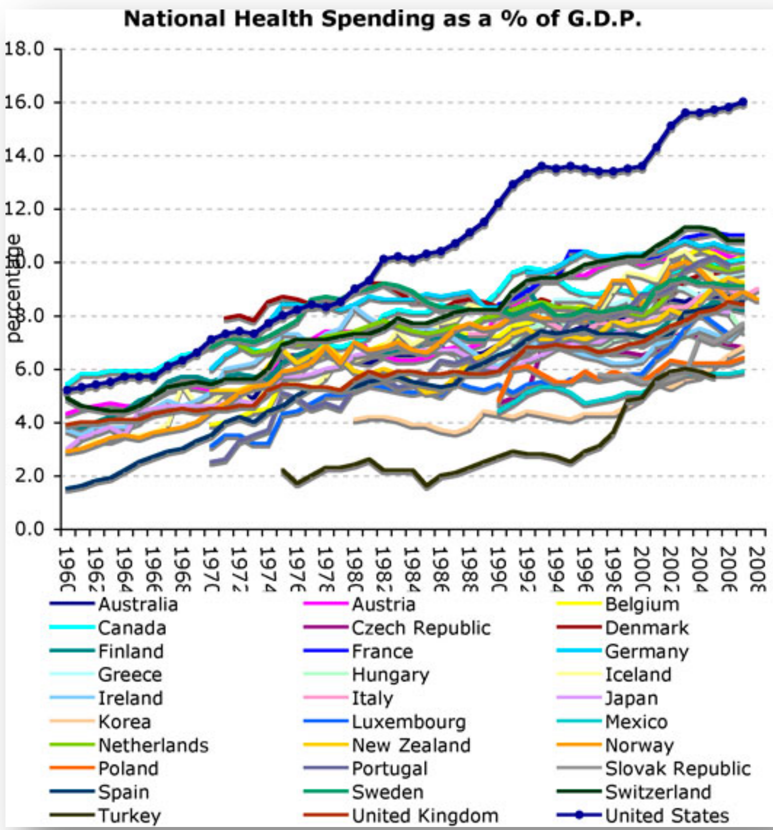


Figure 6 demonstrates a steady increase over the last 50 years on the % of G.D.P allocated to healthcare. (http://economix.blogs.nytimes.com/2009/07/08/us-health-spending-breaks-from-the-pack/)

Since 1980, health expenditures per capita in the United States have more than tripled since 1980, and the average for the rest of the member countries, where data was available, has more than doubled. [35]

VHI

The Irish Economy newspaper (Jan 2010) writes that VHI reported that over the last five years the total number of medical procedures which it paid for on behalf of its customers in private facilities increased from 293,000 procedures to 507,000 procedures, an increase of 73%. It expects this to increase by a further 9% in the year ahead.

It will generate losses of over €170m in meeting the healthcare needs of its 280,000 customers who are sixty years and older. These losses will inevitable increase the costs of VHI policies.[36]

Increasing Demand for Personalized Care Coupled with Cost Efficiency

Health care is a bottomless pit and will remain so despite struggles to contain costs. The results from these findings highlight the need to focus on strengthening healthcare capacity outside of the acute setting (HSE 2007).[37]

After almost two decades of global economic expansion followed by a global recession, many countries are now facing a national reduction of healthcare budgets. In Ireland, the Sunday Business Post reported that the budget for the health service is likely to be cut by up to €600 million next year. Health budgets were cut by more than €1 billion last year, a decrease of nearly 9% (Leahly 2010)[38]. The government in the UK is actively seeking to cut healthcare budgets, and have told the NHS to make between £15bn and £20bn of savings from 2011 to 2014 (Triggle 2010)[39]. This is a trend that is being repeated internationally as many governments seek to find ways to reduce their costs and get out of deficit.

Based on the above issues for the global healthcare systems, it is clear that the current model of healthcare will not be able to cope with the increased burden due to this rise in populations of elderly people and people with long-term conditions. Where the supply cannot meet the demand, it is essential to find new strategies to reduce the demands on the healthcare system so that we can ensure that we do not face an international healthcare crisis.

Advances in technology are providing increasing opportunities to help assist in the above (Harding 2006).[40] Technology will play a key role in the next generation of patient self-care, both in supporting care-related tasks and in allowing providers to monitor and communicate with patients without requiring face-to-face or telephone interaction.

Chapter 3 - Literature Review

Introduction

The structure of our society is changing. Due to advances in healthcare, people are living longer than ever before. At the same time people are living longer, resulting in a growing number of people with long-term conditions such as diabetes, heart disease and chronic obstructive pulmonary disease. People are also better educated and enjoy a better standard of living, and therefore have higher expectations of the healthcare and wellness services that should be provided to them. This is happening at a time of global recession, where many countries are faced with shrinking per capita budgets for healthcare spending and at a time where there is a global shortage of healthcare workers.

With these changes comes a necessity for a shift in the healthcare paradigm. In the traditional model of healthcare, individuals interacted with their doctors only when they were ill, with admittance to hospital for causes that could have been treated or prevented if recognised earlier. Changing demographics, rising long-term conditions and reduced spending are leading to healthcare shortages in terms of beds, lengthy waiting lists and staff shortages.

These changes are contributing to the move towards the concept of "wellness care". This concept incorporates "Connected Health" which focuses on using technology to keep people healthy within their community and home environment and out of hospitals and GP clinics. It also recognises that people need to be better educated on management of their conditions from within the home.

It is essential that we move towards keeping people out of hospitals where possible, and exploit available and emerging technologies to ensure that people can be managed effectively from within their daily environment.

It is important that systems and strategies are developed which can assist a person to live independently and manage their own healthcare conditions in their daily environment, and can also detect early warning signs of complications by the individual's care team. This will help ensure that any issue is resolved before the person ends up in a hospital bed.

This new model of healthcare has many benefits for everyone including increased quality of life and sense of dignity for the individual, peace of mind for family and friends and reduced healthcare spending due to early intervention and increased efficiencies in healthcare delivery.

Remote Patient Monitoring

Definition

Remote Patient Monitoring is the provision of real time patient care, no matter where the clinician is and no matter where the patient is (Prof. Kambiz Madani, 2010).[41] It enables clinician to remotely monitor and manage a patient condition(s) outside of a hospital setting, promoting healthcare at home. It facilitates self-management of personal health and helps to minimize visits to doctors and hospitals. (Telus Website, 2010)[42]

Application of these technologies in preventative healthcare is potentially beneficial for the elderly, but can also help in making provisions for 'equal opportunities' for people from all other age groups suffering from various physical and cognitive disabilities in all aspects of their daily living. (Boulos, Castellot Lou, Anastasiou, Nugent, Alexandersson, Zimmermann, Cortes, Casas 2009) [43]

Early programs as far back as 1998 have demonstrated improved outcomes when the RPM system provides the type of support suited to the patients health management challenge and care situation and importantly is easy for the patient to use (Comput Control Eng 1998)[44].

Frost and Sullivan (2008) divides' the concept of Remote Patient Monitoring technologies into the following two categories, safety/environment monitoring and health/wellness monitoring.

Safety/Environment

Accidents and emergency events are quite common among the elderly when at home. The most popular of the safety technologies are those designed to detect abnormalities in the patient home. Devices such as fall sensors, panic buttons/cords, motion sensors, Carbon Monoxide detector, smoke detector, flood sensors etc. These are embedded-in-the-environment devices. The advantage of these products over the 'wearable' type is that they do not require the user to activate or wear it. However the disadvantage being the system can only be used when the patient is at home. There are Safety/Environmental wearable devices but these prove to be unpopular with the elderly and are rarely carried by the patient. [45]

Health and Wellness

Patients can now monitor glucose, blood pressure levels etc and transfer the readings to a healthcare provider from outside of a hospital/GP practice environment. Physicians can review these vital signs and implement timely intervention. There are also bed pads that can measure things as sleep and restlessness.[46] Please see Appendix 1 for a list of such Medical devices.

Health and Wellness can be further separated into 2 categories:

- Chronic Disease Self-Management – Preventive healthcare
- Post-Acute Self-Care

Chronic Disease Self-Management – Preventive healthcare

Chronic disease management has been the earliest target for organised programs to assist patients in their role as caregiver because of the enormous cost of caring for patients with chronic disease and the growing disease burden among the population (Jimison, Gorman, Woods, Nygren, Walker, Norris, Hersh 2008).[47]

Chronic disease patients, especially those who are elderly and have multiple chronic conditions, must take self-management actions every day, including monitoring status indicators such as blood pressure, respiration rate, blood glucose levels etc and then taking action based on what they learn. For healthcare providers, occasional visits are often not sufficient to evaluate how well patients are doing. This is especially true when working with patients who are elderly, have difficulty managing their disease or possibly multiple chronic diseases and require continuous long-term monitoring of targeted care status indicators such as vital signs, medication compliance and activity levels, as well as intervention from care providers when their health status changes.

The growing volume of literature links the prevalent co-morbidities, such as heart disease, chronic obstructive pulmonary disease and hypertension to a handful of personal health behaviors. This emphasizes the role for prevention in current medical practice in changing the personal health behaviors of patients long before clinical disease develops (HSE 2007).[48]

Tremendous Healthcare cost savings and resources could be saved if patients with chronic diseases could be managed at home.

Post-Acute Self-Care

Post-acute patients require intensive monitoring of vital signs or other condition specific measures in addition to changes in recovery status by care professionals typically over a period of thirty days, but this can vary depending on the severity of the patients condition.

In an effort to reduce inpatient length of stay and decrease unplanned re-admissions many hospitals are integrating post-acute self-care programs into their discharge processes. Effective programs enable patients to communicate frequently with caregivers when necessary and improve medication/treatment compliance and recovery rates. For example, patients who took part in a re-engineered discharge planning process at Boston Medical Center were 30 percent less likely to be re-admitted or visit the emergency room. In addition, the improved discharge process reduced total costs by an average of $412 per patient (Jack 2009).[49]

Although ‘Safety and Environmental’ and ‘Health and Wellness’ both fall into the remote patient category and I will focus primarily on ‘Health and Wellness’ RPM systems and include these systems in my secondary case studies.

Technology Solutions

There is a wide range of technology solutions for supporting the needs of the patient. For purposes of this paper they have been categorised these as follows:

- Patient technologies — those physically located on the patient to collect patient data, these can be attached to the skin or embedded under the skin
- Everyday technologies — mobile phones, PDAs, laptops and PCs, not requiring special equipment
- Medical devices — specially-developed solutions that collect data on physiologic status and communicate with providers as part of a care management program

- Home Embedded technologies— technologies integrated into the home environment[50]

For the purpose of this paper I will focus on a Mobile based Remote Monitoring system:

Mobile Technology

Currently, the most promising technology venue for self-management applications and services is technology that is already part of everyday life: the mobile phone. As these are mobile devices, patients can use them anywhere there is mobile network. They are useful for encouraging healthy lifestyle behaviors, and effective for health maintenance and chronic disease management for active patients.

One obvious advantage of these technologies is that many patients already use the technology. A recent report prepared on behalf of the Agency for Healthcare Research and Quality (AHRQ) found that patients are less likely to use interactive systems that require new equipment or technology that does not fit seamlessly into their normal daily routines (Jimison, Gorman, Woods, Nygren, Walker, Norris, Hersh 2008).[51]

Prof Murro (2006) findings show that wireless systems are less cumbersome for the patient than systems that rely on lengthy cables.[52]

Mobile devices as Services Delivery Platform

Wireless health solutions hold the potential to revolutionize health care, dramatically reducing the costs associated with health care; increasing the efficiency and effectiveness of health care providers; and extending the reach of health care services to nearly every corner of the earth (Vignet Inc. 2009).[53]

In the past the technology was not very effective due to poor communication systems, but now due to the popular use of mobile communication technology, a lot of research effort is being done in the area of healthcare monitoring and services (Ross, 2004).[54]

The existing GSM Networks can be used to provide remote monitoring and healthcare for patients using standard available mobile phones. For healthcare, wireless technologies means new ways to stay in touch with doctors, patients and employees (QURESHI and TOUNSI 2005).[55]

The U.N. telecommunications center has said the number of mobile phone subscriptions worldwide has reached 4.6 billion and is expected to increase to five billion this year. Even during the economic crisis, the U.N. telecommunications agency had seen no drop in the demand for communications services (CBS News 2010).[56]

Phone use with the Elderly

Current studies suggest that people over the age of 65 use mobile phones for very limited purposes, such as for calling or texting[57] in emergency situations (Turel, Serenko, Bontis, 2007). A 'Use of Mobile Phones by Elderly study' showed that the elderly avoid using more complex functions. The major causes cited are:displays that are too small and hence difficult to read tiny handset buttons; too many, complex and sometimes unnecessary functions non-user-friendly menus and unclear instructions on how to find and use a certain function services that are too expensive to subscribe to (Nizam Nasir, Hassan, Jomhari, 2008)[58]

If systems are designed intelligently, technology promises to enhance their quality of life of older people and those suffering from various physical and cognitive disabilities and to provide them with new opportunities to live independently that were unthinkable of a few years ago.

Healthcare provider's opinion of RPM is expected to gradually change when today's generations of younger people who were born and educated in the Internet age and the era of personal and mobile computing. As these people get older they are more familiar and comfortable than the current generation of senior citizens over the age of 65 having used them for most of their lives for study, work and leisure.

Benefits of mobile phone wireless technology

The latest generation mobile smart phones offer opportunities for substantially improving healthcare processes and providing solid communication framework for staff members. Technology advances include:

- Strengthened communication security, in support of patient privacy regulations
- Push data delivery, ensuring prompt notification in the event of medical crises
- Dual-mode connectivity (combining cellular and Wi-Fi), minimizing barriers to communication inside buildings or while traveling
- Single point of contact through integrated smart phone applications, providing better coordination of communication tasks among doctors, nurses and support staff members
- Improved access to vital electronic health records(EHR), decision support tools, medical references and similar resources
- Continual improvements to network speed, reliability and coverage
- Wireless network create near universal internet access - goes where cable and fiber cannot: the inherent nature of wireless is that it doesn't require wires or lines. As such, the system will carry information across geographical areas that are prohibitive in terms of distance, cost, access, or time(http://www.kimaldi.com/kimaldi_eng/area_de_conocimiento/tecnologia_wireless/ventajas_tecnologia_wireless)[59]
- Combines functionality, voice and data

Spyglass Consulting Group reported that 82% of the physicians surveyed prefer a single communication device that combines functionality rather than a collection of pagers, cell phones, PDAs and other devices. In institutions that have adopted wireless technologies, studies indicate marked improvements in workflow efficiency.

A leading Canadian healthcare organisation with over 2,000 staff members performed a cost benefit analysis of a mobile communication solution to be deployed in their facility. The analysis concluded that the voice and text communication benefits alone would recover up to 12% percent of a nurse's time, which could then be directed to improved patient care. This organisation calculated annual savings for their staff of almost US$ 16 million annually, equal to the work performed by 192 full-time nurses. Similar or higher levels of savings were demonstrated for other healthcare worker specialties.[60]

Medical Device Technologies

Medical device technologies for self-management, both commercial products and home-grown solutions, focus on long-term health and disease monitoring and treatment compliance for patients with chronic conditions and the elderly. These devices collect data from a variety of connected sources such as a, blood pressure monitor, peak flow monitor, glucose monitor, insulin pump, digital spirometers etc. Please see Appendix 1 for a list of medical devices and their corresponding diseases.

Combining Mobile and Medical Device Technology

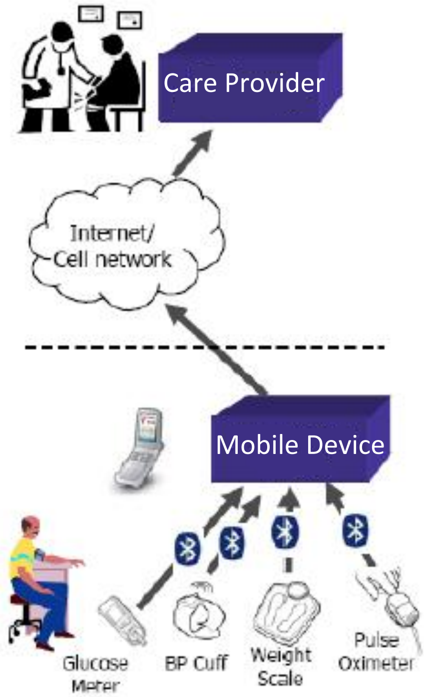


Figure 7 Shows a patient taking their vital signs readings from a medical device and sending it through a mobile phone to the care provider. *(Page 17* Mobile enabling Connected Health industry, Continua Health Alliance, 2009, Prepared for The Continua Alliance by Vignet Inc. September 2009)

1. A patient with a chronic condition (e.g. CHF, Diabetes) or one who is recovering from a condition, uses one or more Bluetooth enabled medical device (e.g. blood pressure cuff, weight scale, Pulse oximeter, etc.) to collect vital sign data at various times during the day or week.
2. Once the patient takes a reading with the medical device, the patient will select the option to transmit the vital signs data (on some devices this can be done automatically after a reading is taken) from the medical device to a Bluetooth enabled mobile phone/PDA/Laptop.
3. The Bluetooth-enabled Mobile device then automatically transmits the data within a secure network (GSM/GPRS/TETRA) to a central database.
4. Built-in intelligence at server level will monitor readings and in case of any emergency, an alert can be sent a clinician/patients spouse.
5. Data is stored in Personal Patient Database.
6. Clinician can access the health records via mobile phone or computer connected to Internet, and can take appropriate steps.

7. The clinicians can view this information anytime and can use it to help the patient manage their condition (Vignet Inc.).[61]

Health and Wellness case studies (Secondary Data)

The case studies I have selected to include in my thesis are case studies that have been carried out by healthcare organisations (as opposed to IT companies who might modify their case studies results to sell more products). I have included 4 case studies to show that the Remote Patient Monitoring Systems had been very successfully deployed by health organisations as early as 2003 with very promising results. Case studies include:

- Canadian Case Study with Black Berry
- World-First Full-Scale Clinical RCT with High-Risk Patients
- MOBIle Telemonitoring in Heart Failure Patients
- Veterans Administration

Other case studies include:

- Pediatric Case Study
- Yale University School Of Medicine Study

Canadian Case Study with Black Berry

(Dr Joseph Cafazzo 2006)

In a Canadian government funded trial, UHN (University Health Network) and Mount Sinai Hospital investigated various home tele-monitoring systems for Type II Diabetes patients. In a 33-patient trial for Type II Diabetes, conducted in 2006, BlackBerry smart phones emerged as a viable alternative; the solution showed it could increase patient involvement in their own healthcare, without adding more pressure to the healthcare system.

Technology Performance Results

- Cost-effective Solution
- Secure Way to Transmit Patient Data
- Simplified Development
- Flexibility and Control with Applications

Clinical Results

In the pilot study, 24-h ambulatory BP fell by 11/5 mm Hg, and BP control improved significantly. Substantially more home readings were received by the server than expected, based on the preset monitoring schedule. Of 42 BP alerts sent to patients, almost half (n 20) were due to low BP. Physicians received no critical BP alerts. Patients perceived the system as acceptable and effective.[62]
Please see Appendix 3 for the full details of case study.

World-First Full-Scale Clinical RCT with High-Risk Patients

(Robinson, Stroetmann, Stritetmann 2003)

The aim of the TEN-HMS (homecare management system) project was to scientifically test whether RPM can improve medical outcome for the heart failure patients as well as their quality of life and the efficiency of healthcare processes.

426 patients with a recent exacerbation of chronic heart failure were selected. University and regional hospitals in Germany, the Netherlands, and the UK as well as local specialists and GPs were involved. By a random selection process, patients were selected for one control and two intervention groups:

1. The Usual Care (UC) group comprised 85 patients
2. The Nurse Telephone (NT) group comprised 173 patients
3. The RPM group comprised 168 patients

Results

- RPM and NT patients, had a substantially and significantly lower mortality rate compared to patients obtaining usual care
- Admissions into hospital were slightly higher for the RPM group than for NT group, but the mean duration per admission were considerably lower, up to 25%. Overall, the total days in hospital were considerably and consistently lower for the TM group
- Cost saving with the overall reduction in hospital bed-days more than offsets the increased cost of RPM compared to nurse telephone monitoring
- 90% of RPM patients were very enthusiastic about this kind of support[63]

Please see Appendix 4 for the full details of case study.

MOBIle Telemonitoring in Heart Failure Patients

(Scherr, Kastner, Kollmann, Hallas, Auer, Krappinger, Schuchlenz, Stark, Grander, Jakl, Schreier, Fruhwald, FESC, 2008)

The goal of the MOBIle TELemonitoring in Heart Failure Patients Study (MOBITEL) was to evaluate the impact of home-based Telemonitoring using Internet and mobile phone technology on the outcome of heart failure patients after an episode of acute decompensation.

The recruitment for this study started on October 1, 2003, and was closed with the sign-off of the last patient on April 29, 2008.

Patients were randomly allocated to pharmacological treatment (control group) or to pharmacological treatment with RPM surveillance for 6 months. Patients randomized into the RPM group were equipped with mobile phone–based patient terminals for data acquisition and data transmission to the monitoring center.

Results

- 12 RPM group patients were unable to begin data transmission due to the inability of these patients to properly operate the mobile phone ("never beginners").
- Four patients did not finish the study due to personal reasons.
- Intention-to-treat analysis at study end indicated that 18 control group patients (33%) reached the primary endpoint (1 death, 17 hospitalizations), compared with 11 RPM group patients (17%, 0 deaths, 11 hospitalizations; relative risk reduction 50%).
- Per-protocol analysis revealed that 15% of RPM group patients (0 deaths, 8 hospitalizations) reached the primary endpoint (relative risk reduction 54%, 95% CI 7-79%, *P*= .04).
- NYHA class improved by one class in RPM group patients only.
- RPM group patients who were hospitalized for worsening heart failure during the study had a significantly shorter length of stay (median 6.5 days, IQR 5.5-8.3) compared with control group patients (median 10.0 days, IQR 7.0-13.0; *P*= .04).
- The event rate of never beginners was not higher than the event rate of control group patients.[64]

Please see Appendix 5 for the full details of case study.

Veterans Administration

(Meyer, Kobb, & Ryan. 2004)
I have included this case study as it shows the huge savings this RPM system has saved both financially and for the patients health.
In a RPM study of the Veterans Administration (VA), the Community Care Coordination Service deployed RPM to 791 high-risk, elderly veterans with hypertension, heart failure, diabetes, or chronic obstructive pulmonary disease (COPD) – five of the most costly conditions.

Results

After one year, the VA found:

- 40% reduction in emergency room visits
- 63% reduction in hospital admissions
- 64% reduction in nursing home visits
- Significant improvement in patients' perception of quality of life[65]

Pediatric Case Study

(http://www.continuaalliance.org/connected-health-vision/disease-management.html)
I have included this case study to show that patients of all ages can use RPM systems.
Ayesha is a twelve year old who has just been diagnosed with juvenile diabetes. She uses a glucose meter and cell phone to monitor her blood sugar levels. The cell phone reminds Ayesha to check her blood sugar regularly during the day, and her glucose meter seamlessly transmits her measurements to her cell phone after each use. The data is transferred to a diabetic monitoring service that maintains Ayesha's long-term history and looks for abnormal events. If a reading is unusual, or if Ayesha skips a test, the system automatically contacts her mother, who can get in touch with Ayesha immediately using her cell phone. [66]

Yale University School Of Medicine Study

(http://www.mobilehealthwatch.com/blog/proving-value-rpm)
The Yale University School of Medicine recently enrolled 1,650 heart failure patients as part of a National Institutes of Health sponsored study to examine the impact of device-free remote patient monitoring on improving chronic care management and reducing hospitalizations of HF patients. The results of this trial have not been released yet and I have included this to show it is a clear indication that research institutes believe that RPM can significantly benefit the healthcare industry.[67]

RPM Market

EU and US

The European Union and the US are the two dominant markets that use connected health in homecare service.

Frost and O'Sullivan study

Analysis from Frost & Sullivan into European remote patient monitoring markets, says that the quality and benefits of the technology is making it increasingly attractive to vendors across the continent. The study found that the remote monitoring market earned revenues of €11m in 2007 and estimates this to reach €253 million in 2014.

New analysis from Frost & Sullivan (http://www.patientmonitoring.frost.com, 2010),[68] Data Management Systems for Patient Monitoring Markets in Europe, finds that the markets earned revenues of $126.8 million in 2009 and estimates this to reach $161.4 million in 2013. The markets covered in this research service are electrocardiogram (ECG), sleep and respiratory, neurological and anaesthesia.

"The heightened demands of an ageing population and a related increase in chronic diseases are encouraging market growth," said Frost & Sullivan's research analyst, Janani Narasimhan (2008).[69] Please refer to Appendix 2 to see specific countries revenue forecasts. Countries include:

- France
- Germany
- Italy
- Spain
- UK
- Benelux - Belgium, the Netherlands, and Luxembourg
- Scandinavia – Denmark, Norway and Sweden

SUNY Fredonia 2008 study

According to a January 2008 the Suny Fredonia research study conducted at the State University of New York at Fredonia, the demand for patient monitoring systems in the primary healthcare sector in the United States is forecast to increase 5.9 percent per year to an estimated $12 billion market by 2012 based on expected contributions to positive therapeutic outcomes and efficiencies. Additionally, the study indicates that the market for self-monitoring activities will also expand as treatment for chronic care patients, especially patients with asthma, diabetes and heart disorders focuses on preventative care.[70]

SpyGlass study

According to the Spyglass Consulting Group study ‘Trends in Remote Patient Monitoring’ (2009), an estimated 97 percent of healthcare organisations rely on remote patient monitoring to improve clinical outcomes for critically ill patients, the study says. Forty-eight percent of healthcare organisations interviewed have funded home telehealth initiatives themselves. A strong return on investment exists as seen in the case study for the Veterans Administration.[71]

IBM - High Costs Curb Adoption Rate

The revenues for the European RPM market were 175.0 million in 2007 and are expected to hit 400.0 million by 2014. The market is characterised by a reasonable growth rate. The market is likely to grow at a compound annual growth rate (CAGR) of 12.5 per cent from 2007 to 2014. The main driver for the market is increased demands of an aging population in Europe. The increased dependence of healthcare processes on general practitioners for constant advice to patients acts as a major market restraint. Among the European countries, the United Kingdom is the single largest contributor of revenues, followed by Germany, Italy, France, Benelux, Scandinavia and Spain (http://www-07.ibm.com/solutions/au/healthcare/mobilitysolutions/remote.html).[72]

Slow growth

These studies show a strong growth in the market (as compared to previous years) over that last 3-4 years and envisage this for the foreseeable future but the growth is still slow. Remote Patient Monitoring has existed globally for some time now and with the well documented problems in healthcare and the potential RPM has, so why the slow growth? In no particular order, here is a list of some of the potential reasons for the slow growth of RPM:

1. There are still some privacy and confidentiality issue regarding electronic data. Healthcare providers believe sending patient health details over the internet exposes this data to more hostile attacks compared to the paper-based medical records.
2. An elderly person can find it difficult to adjust to the changing technology resulting in resistance to the adoption of new technology.
3. Standardisation acts as a major restraint although the efforts are being made from the Continua Alliance.
4. A key issue with the growth of RPM is the governments' refusal to reimburse remote healthcare providers of monitoring of patient populations. With no financial incentive for healthcare providers to implement the technology, clinicians are likely to view RPM as an increase in workload without an increase in pay.
5. Following on from point 4, with the deployment of RPM systems GP clinics could experience a drop in revenues as the main goal of RPM is improve patients health and keep them at home resulting in lesser visits to the GP's clinics. Government/Payers reward healthcare providers for the quantity of the procedures performed rather than the quality of care delivered.
6. There is a lack of awareness about the seriousness of chronic diseases and how they are going to increase with the ageing baby boomers.
7. Fast changing technology makes it difficult for providers to maintain the growth. With each passing year, technologies become obsolete. Systems need to be developed in such a way that any upgrades/innovation in technology could be easily uploaded.
8. There is a severe lack of EHRs and their ability to integrate with RPM systems. One of the main selling points for an RPM system is that the data captured from the patient remotely can be attached to the patients EHR.
9. The high cost of RPM systems! Who pays for it?? (Frost and Sullivan 2008)[73]

Market Drivers

Based on the above issues for the global healthcare systems detailed in Chapter 2, it is clear that the current model of healthcare will not be able to cope with the increased burden due to this rise in populations of elderly people and people with long-term conditions. New solutions are desperately needed and this is driving force behind RPM. The right RPM system could take a huge burden off the current healthcare systems.

American Heart Foundation View

The American Heart Association and other health institutes highly recommend that those suffering from high blood pressure invest in blood pressure systems for their homes. Home monitoring units have both advantages as well as disadvantages. Home units are more affordable, convenient and portable. It further saves time and money since a patient would need fewer trips to the doctor. The main downside to home units is that they are less accurate than commercial units and are often operated by individuals without any medical background or training..
(http://www.amaassn.org/amednews/2008/12/22/bisb1222.htm, 2009)[74]

Chapter 4 - RPM Benefits and Recommendations

RPM Benefits

Benefits for Patient

- Peace of mind and improved quality of life, patient can live a normal life uninhibited by their condition.
- Monitoring patients remotely improves patient care by collecting vital patient information on a daily basis from the patients home without the need for a clinician or caregiver to be present, thus eliminating gaps in patient monitoring (Meyer, Kobb, & Ryan. 2004). [75]
- Documenting vital signs and symptoms from the home without the intervention of a clinician, empowers patients to better controls contributing factors which can exacerbate their health conditions, such as diet, exercise, alcohol, insulin and medication use, and stress levels, translating into higher patient satisfaction. (Meyer, Kobb, & Ryan. 2004). [76]
- Lightweight and easy to use, the patient can carry the device around and monitor themselves no matter where they are.
- Easy to reach health care services
- Reduced clinical visits to hospital saving time and travel expenses
- Enhanced Diagnostic Services and Disease Management
- Enhanced Emergency Response System
- Reduction of Medical Expenditure
- Better medication compliance
- Encourage healthy habits – the patient has more robust participation in their own health care and a normal life at home, uninhibited by their condition.
- Early warning device and prevent serious complications from ever happening
- Enable regular and engaging patient-provider connections (Cleland, Balk, Janssens, Uwe, 2005)[77]
- Clinical tests may also cause undue stress on some patients and distort the results. In these cases, home testing can provide a clearer picture of a patients true condition.
- RPM has been shown to produce better health outcomes. For example, studies demonstrate that RPM helps reduce HbA1c levels in patients with diabetes by up to 15 percent after just six months (Diabetes Technology and Therapeutics, 2003) [78].

- Seeing blood pressure improvements – or deterioration – regularly may help motivate a patient towards better health.

Benefits of Patients family

- Patients relatives have some piece of mind and reassurance knowing that their relative is being monitored.

Benefits for Physician

- Significantly upgrades the physician's method of treating patient
- Cumulative patient records assure accuracy of records
- Provides real time access to computerized, comprehensive information for each patient
- Significant improvement in medication management
- Clinicians can manage these patients remotely while spending most of their time with high-risk patients

Benefits for Hospital

- Early Patient Discharge
- Reduced Hospitalisation for Chronic patients
- Improved services and quality for home care patients
- Greatly improves income generation and strengthen patient relationship
- Identify high-risk patients and intervene earlier (Meyer TE, Shreve)[79]
- Establishing Infrastructure for a Growing Population
- RPM delivers reliable evidence of compliance through regular, real-time physiological readings. This monitoring process helps compel patients to follow prescribed therapies, and recent studies have shown that it can increase compliance by nearly 40 percent. (Berg, Gregory 2002)[80]
- When patient information is limited, choosing an effective treatment can be challenging. However, RPM offers a detailed picture of each patients situation, based on weeks — or even months — of reliable data collection. This history enables more informed treatment decisions and helps increase the chances for a better health outcome. (http://enterprise.alcatel-

lucent.com/private/active_docs/RMK7526090608_TeleHealth_Manager_healthcare_market_EN_Brochure.pdf)[81]

- Provides easy access to accurate information, which contributes to more informed treatment decisions, improved clinical efficiency and significant financial benefits.
- RPM helps healthcare providers make better use of their time — and data resources. For example, it reduces office visits through remote monitoring of patients with mild conditions, allowing those hours to be redirected to a larger number of patients — or focused on high-risk cases. (http://enterprise.alcatel-lucent.com/private/active_docs/RMK7526090608_TeleHealth_Manager_healthcare_market_EN_Brochure.pdf)[82]
- Collaboration can also be more efficient, because multiple healthcare providers can view the same online data simultaneously, helping to prevent confusion and administrative errors (http://enterprise.alcatel-lucent.com/private/active_docs/RMK7526090608_TeleHealth_Manager_healthcare_market_EN_Brochure.pdf) [83]
- Fees for homecare nurses can add up quickly, especially in an era of rising transportation costs – will result in less nurse home visits
- Third-party healthcare payers and insurers now face the financial consequences of an aging society — and more pervasive chronic diseases. RPM can play a valuable role in cost containment, which has become a crucial priority.
- Reductions in acute and intensive care:- Patients with chronic medical conditions often suffer from related health issues that require acute care and, in some cases, surgery. RPM can significantly reduce the high costs of this healthcare — by monitoring and managing chronic conditions before avoidable related health issues develop.
- This proactive approach reduces expensive claims, while improving the quality of patients' lives.
- Improve survival rates (Cleland, Balk, Janssens, Uwe, 2005)[84]

Benefits for Pharmaceutical Companies

- Enhanced product sales with longer living chronic patients.
- Extend Disease Management programs for chronic patients.

Benefits for Insurance Companies

- Significant reduction in unnecessary hospitalisation
- Significant savings from early hospital discharge
- Significant reductions in visits to emergency facilities
- Enhanced Research and Clinical Trials
- Enhanced Professional Support (White Paper on Mobile Health Monitoring)[85]

Recommendations

Below is a list of recommendation

1. If technology is made seemingly less complicated and more user-friendly, then the problem of resistance from the elderly would be reduced. Ideally technology should work in the back ground with minimal user interaction required as possible(Frost and Sullivan, 2008)[86]
2. Interoperability with EHR's
3. Incentives must be given to clinicians to help push RPM
4. Use tried and tested technology that is already available to minimize costs
5. Creation of technology that is interoperable and capable of being integrated into the systems and solutions of market participants is also a requisite for success. (Frost and Sullivan, 2008)[87]
6. Convergence with consumer electronics products enables patients to use devices with which they are already comfortable, including smart phones and personal computers. Prices for remote patient monitoring devices need to drop from several thousand dollars to less than $500 per unit before healthcare organisations will make further investments to support their patients with other chronic diseases.(Spyglass Consulting Group 2009) [88]
7. To tackle privacy and confidentiality issues related to remote patient monitoring, market participants could lobby for an EU-based regulatory response for the creation of a specific code of conduct for sharing health information (Frost and Sullivan, 2008)[89]
8. Patients and families continue to have a growing interest in attaining and maintaining good health and are more active in care management. Incentives are needed in parallel with education about what is possible and why it is important.
9. Organised programs supporting self-management are essential
10. Clinicians need to be the central resource to help patients navigate the possibilities for self-care management program options, especially those that involve ongoing chronic disease monitoring and overall management.

11. Patients must be committed to good health and act as both the provider of care and the key collaborator with the primary care physician, participating in self-care programs and adhering to customized care plans. (Turisco and Harmon, 2009) [90]
12. Consider how the health care organisation should adapt to make best use of the introduction of technology. Simply installing technology to do the same as before, without considering how the process might be changed, and without providing the new infrastructure and service to support the technology, will not only undoubtedly result in failure, but also fail to gain full benefit of use of the new technology. (Clarke, Jones, Bratan, Larkworthy, 2009).[91]

Chapter 5 –

Vivasta RPM Safety and Environment Pilot

Introduction

It is recognised that there is a requirement for an open software platform that can handle data from multiple telehealth, telecare and other “assistive” devices and present this data in multiple locations so that the correct action can be taken promptly.

The platform should be able to handle data in different formats from multiple device manufacturers and provide a range of interfaces including web, desktop, mobile phone and smart-phone to enable interaction by all members of the individual’s care network including family and friends. This platform should also share all data collected with third-party systems including doctor’s records and online personal health records.

Vivasta is an end-to-end managed care platform designed to meet these requirements.

The Vivasta team kindly agreed to let me be involved in the pilot of this exciting system. The pilot was originally due to commence in January 2010 with a full RPM system including Health and Wellness, and Safety and Environment for 10 patients. Due to funding cut backs the pilot was delayed for 6 months commencing in June and the pilot was required to be re-structured into different phases:

- Phase 1 will consist of a RPM Safety and Environment pilot being deployed in 4 voluntary patients homes – door sensors, panic button, bed occupancy sensor, fall detectors and motion detectors.
- Phase 2 of the pilot will see the patients homes upgraded with health and wellness devices – blood pressure cuff, pulse oximeter, thermometers, and for the 2 Diabetic patients a Glucometer.
- Phase 3 will see an increase number of patients added to the pilot and a control centre 24/7 manned with clinician to monitor the data.

Pilot

The purpose of the pilot is to show that elderly/chronic disease pateints can live independently and be monitored by health care professionals without them having to use complex computer systems.

This pilot is a technology pilot to show that a system of this nature can be deployed and can function in a patients home with very minimal patient interaction. Phase 1 will not be used for any clinical benefits and the patients will continue with all care and visits as they would have normal.

Device Independent

The Vivasta system includes a home terminal ("hub") that will gather data from a range of devices in the home into a single repository for transmission to relevant caregivers as required.

The system is compatible with both wireless interfaces (including Bluetooth, RF, IR & WiFi) and wired interfaces (including USB, Ethernet and RS232). It will accept data in a range of formats, including data from Continua-certified devices.

The Continua Alliance, Global Consortium of Personal Tele-health has been formed which include companies like Intel, IBM, Motorola, Oracle, A&D, Pricewaterhouse, Sharp, Cardionet, Card Guard, Omron, Philips, Pfizer, Microlife, GE Healthcare, Medtronics, Roche, Siemens, Polar, Dell, Body media, etc. The objectives of alliance are:

- Developing design guidelines that will enable vendors to build interoperable sensors, home networks, tele-health platforms, and health and wellness services.
- Establishing a product certification program with a consumer-recognizable logo signifying the promise of interoperability across certified products.
- Collaborating with government regulatory agencies to provide methods for safe and effective management of diverse vendor solutions.
- Working with leaders in the health care industries to develop new ways to address the costs of providing personal tele-health systems. (Vignet Inc. September 2009)[92]

The range of devices that the system integrates with is always increasing. The system integrates with both telecare and telehealth sensors and devices, as well as a range of additional sensors. Sensors and devices that are integrated include pendants, panic buttons and pull cords, fall detectors, motion detector, environmental sensors such as flood, smoke, ambient temperature, gas or carbon monoxide, doors/window contact sensors, bed and chair pressure sensors, blood pressure cuffs, glucometers, apnea monitors, arrhythmia detectors, digital pillboxs, fall detectors, thermometers and weighing scales.

Real-time alerting

There will be a number of sensors installed in each patients home. The system transmits all collected data back to a monitoring centre application, to provide 24x7 emergency event monitoring and direct communication with the individual's care team via audio/video conference. For the purpose of the pilot the monitoring application will be monitored during office hours and some evening times.

The system incorporates sophisticated analysis and pattern recognition tools to trigger alerts for anything that is identified as an abnormal or an emergency event. When an alert occurs, monitoring centre staff can rapidly make an assessment of the situation by using data already available and/or by establishing an audio/video link with the individual or their care team, where appropriate, ensuring that all alarms raised are dealt with in an efficient and coordinated manner.

Test Lab

A test lab was set up simulating the full Health and Wellness, and Safety and Environment system for a patient with multi[le chronic diseases. A wide range of devices are installed to simulate a real worlda real world patient home. The table below shows an example of the data that will be viewed once a full system is installed in a paients home. The table shows us the data captured over a 7 day period. You can see from the table all test alerts that were automatcially sent from this 'Test' patient. These alerts would have been sent in almost real-time (average2 second delay).

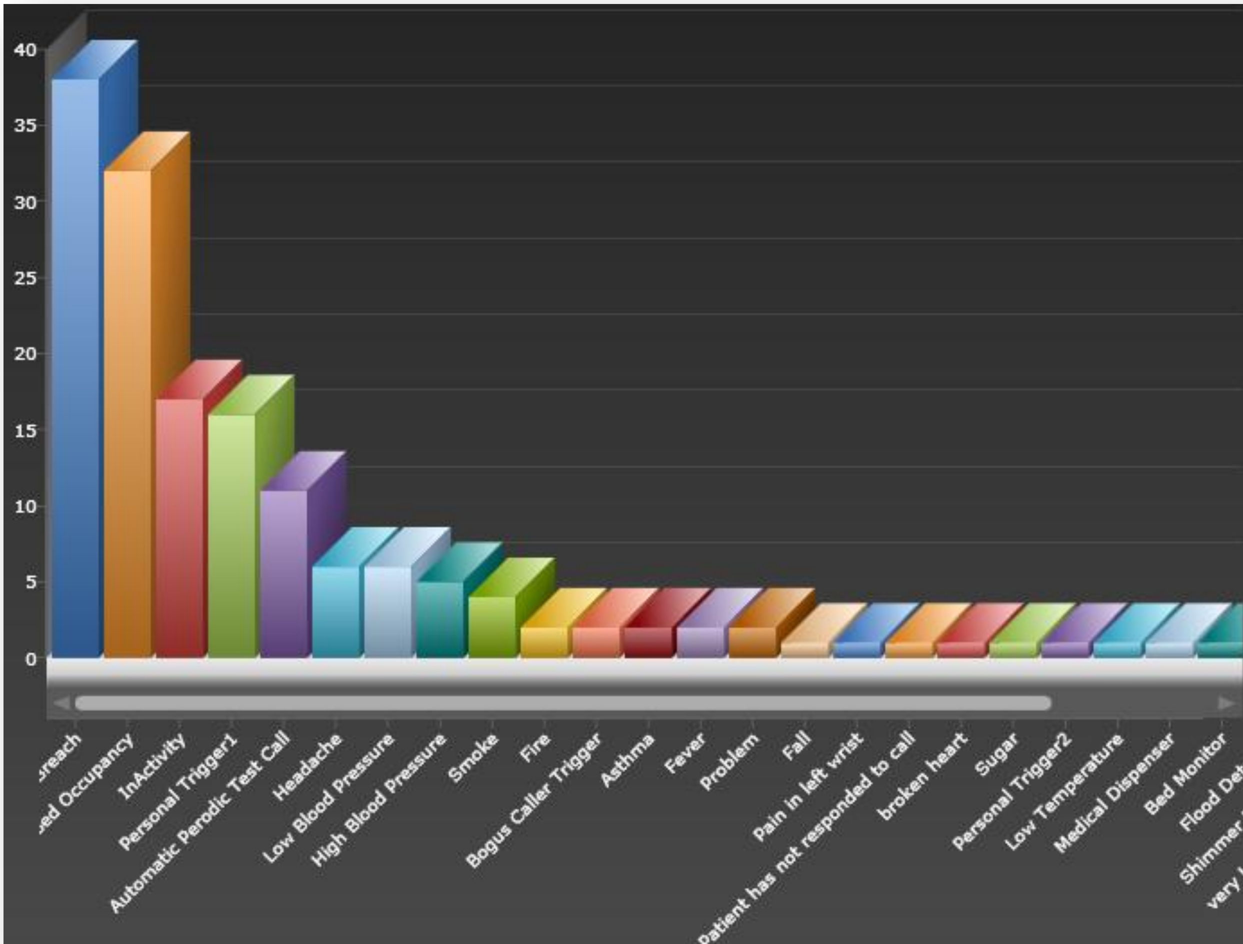


Figure 8

Each alert sent will can be viewed individually showing the specific information relating to that alert i.e. whether the patient has fallen or if the patient had taken some vital sign readings. This table is to give the reader an overview of the type of system that will eventually be deployed in patients homes. The 'Test' patient data has no effect on the pilot as the data had been collected by Health IT specialists and it is not classified as pilot data.

Pilot participants

Pilot participants are patients connected with members of the Vivasta team. They are either a family member or close family friend that had agreed to have sensors installed in their home to help with this pilot. 4 elderly patients, 3 living alone, had been selected to participate in the pilot. Any references to patients will not be disclosed at any point in this report. It is important to note here that there was no patient interaction required during this pilot unless the patient pressed various panic buttons located throughout their home. Patients were instructed to deal with any emergency event as they would normally and not to rely on this pilot system as it was not being monitored 24/7.

For patient confidentiality reason I have labeled the patients as follows:

- Patient_Mary
- Patient_John
- Patient_Agnus
- Patient_Sean

It is important to note that the first names used are not the first names of the patients.

Sensors installed

The sensors conform to the BSI British Standard. British Standard specifies requirements for the transfer of information and controls within a social alarm system, by means of dual-tone multi-frequency (DTMF) tone signals passing between site control or local equipment and an alarm receiving centre via the public switched telephone network (PSTN) supporting voice traffic conforming to ITU-T Recommendation G.711 .

Conforming to this standard ensures that other electronic devices around the home, such as microwaves will not interfere with the sensor devices.

Each sensor around the home will send a unique code to the ARC (ARC & HUB – single device attached to the telephone line, similar to a modem); the hub will then forward this message onto the Vivasta servers over a telephone line. The message sent by the local unit and controller to the ARC shall consist of the sequence:

A CC TT GGGGGGGG RRRR EEE LL P SS XX # where:

A and # are the message string start and stop delimiters; CC is the two-digit system configuration, to indicate the type of equipment TT is the two-digit system type assignment, to indicate to the ARC whether the local unit and controller is using the standard protocol or a proprietary variant; GGGGGGGG is the eight-digit controller identification field, to uniquely define the identity of the specific site/installation; (BSI, 2009) [93]

Below you can see the type of devices that were installed in the patients home.

Bed Occupancy Sensor

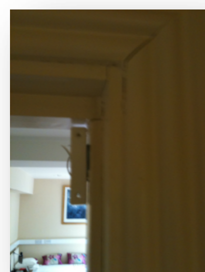
CO and Smoke detectors

Panic Cord

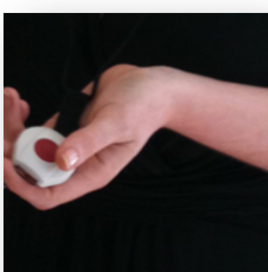
Bed Panic Button

Camera

Door Sensor



Wearable Panic Button



Blood Pressure Cuff (Phase 2)

Inactivity sensor

The Camera can be activated from the control center if there is peculiar behavior or lack of movement from the patients home. The camera was deployed in only Patient_Mary's home.

On Phase 2 of the pilot, the system will use wireless interfaces such as Bluetooth to collect health related information generated by medical devices commonly used in the home, such as blood pressure cuffs, glucometers, thermometers and weigh scales.   Below you can see a Vivasta team member during testing phase of the deployment using a BP cuff and Oximeter.

Sensors installed in patients homes

Each patient had the following sensors installed in their homes.

- Bed Occupancy Sensor. This sensor will send an alert to the Vivasta system when the patient gets out of bed.
- Door Sensor - kitchen, living room, main bedroom, front door and back door. These sensors will send an alert to the Vivasta system when the patient opens a door in the house that a sensor is attached to.
- Carbon Monoxide and Smoke detector. If either Carbon Monoxide or Smoke is detected the corresponding device will alarm to alert the patient and it will also send an alert to Vivasta system.
- Panic alert - Panic Cord, Bed Panic Button, and Wearable Panic Button. When activated this device will send and alert to Vivasta system.
- Fall sensors – The fall sensor will detect any abnormal human movement indicating that a patient has fallen; when this is trigger an alert will be sent to the Vivasta system.

An additional ‘Inactivity sensor’ was installed in ‘Patient_Sean’ home as it was appropriate for his living environment.

- Inactivity sensor. This sensor is placed in an area where a patient is normally active during a particular time of the day. For example say the patient makes dinner in the kitchen daily between 5.30 – 6.30 p.m., this sensor could then be placed in the Kitchen and if there is no activity between 5-7 p.m. then an ‘Inactivity’ alert would be sent to the Vivasta platform.

My role in the pilot

My role in the pilot was to assist the Vivasta team on the installation of the system and to analyse the data received at control center to ensure the sensors where transmitting data. During deployment I was involved in ‘Environmental assessments’ of patient home to determine appropriate locations for the sensors. Please see the home assessment for each patient in Appendix 6. During the test phase of the pilot I was required to visit the patients home to re-locate sensors as analysis of the data showed some sensors were not functioning correctly due to doors being left opened and other environmental issues. The picture to the right shows Vivasta monitoring center. Both I and the Vivasta team member are monitoring the data from the 4 patients home’s in almost real time. It is envisaged that when this system goes Live after Phase 2 of the pilot the monitoring center will be monitoring 24/7 by qualified clinicians (most probably qualified paramedics/nurses) and IT staff.

Pilot Outcome

The results I wanted to obtain from the study was to show patients could live independent in their home and could be monitored 24/7 without the patient having to interact with a complex software system.

Results from the Pilot

Figure 9 below shows the volume of alerts sent to the Vivasta system during the initial 12 week pilot, from 04st June 2010 to 27th August 2010.

	Patient_Mary	Patient_John	Patient_Agnus	Patient_Sean
Bed Occupancy	612	354	516	1
Door Sensor	656	368	491	1088
Automatic Periodic Test Call	38	21	20	32
Personal Trigger	32	17	16	24
Inactivity	0	0	0	8
Mains Power Alert	0	0	0	2

Figure 9

We will take a closer look at these results. It is important to note the following:

- Automatic Periodic Test Call – is a device call to the Vivasta platform to let the system know all devices are alive.
- Main Power Alert – is a device call from the ARC/HUB when the power has been switched off on this unit. The unit has an internal battery when it detects the power mains or electricity has been cut off in the house and automatic alert will be sent.
- Personal trigger alerts were executed by the Vivasta team while visiting the patients. These were random alerts to ensure the devices were working as expected.
- There were no 'Smoke detector' or 'Carbon Monoxide' alerts sent during the pilot for any of the 4 patients.

Participant 1 Patient_Mary

From the captured data we were able to see that the sensors performed as expected at this patients home with quite a high volume of alerts processed by the Vivasta system.

	Patient_Mary	Patient_John	Patient_Agnus	Patient_Sean
Bed Occupancy	612	354	516	1
Door Sensor	656	368	491	1088
Automatic Periodic Test Call	38	21	20	32
Personal Trigger	32	17	16	24
Inactivity	0	0	0	8
Mains Power Alert	0	0	0	2

Figure 10

We could see some abnormally high results for the 'Bed Occupancy' alerts but after an investigation it was uncovered that a grandchild of the patient had been using the bed as a bouncy castle. At least this showed us that the 'Bed Occupancy' sensor was durable. Figure 11 shows us an over view of this patients results.

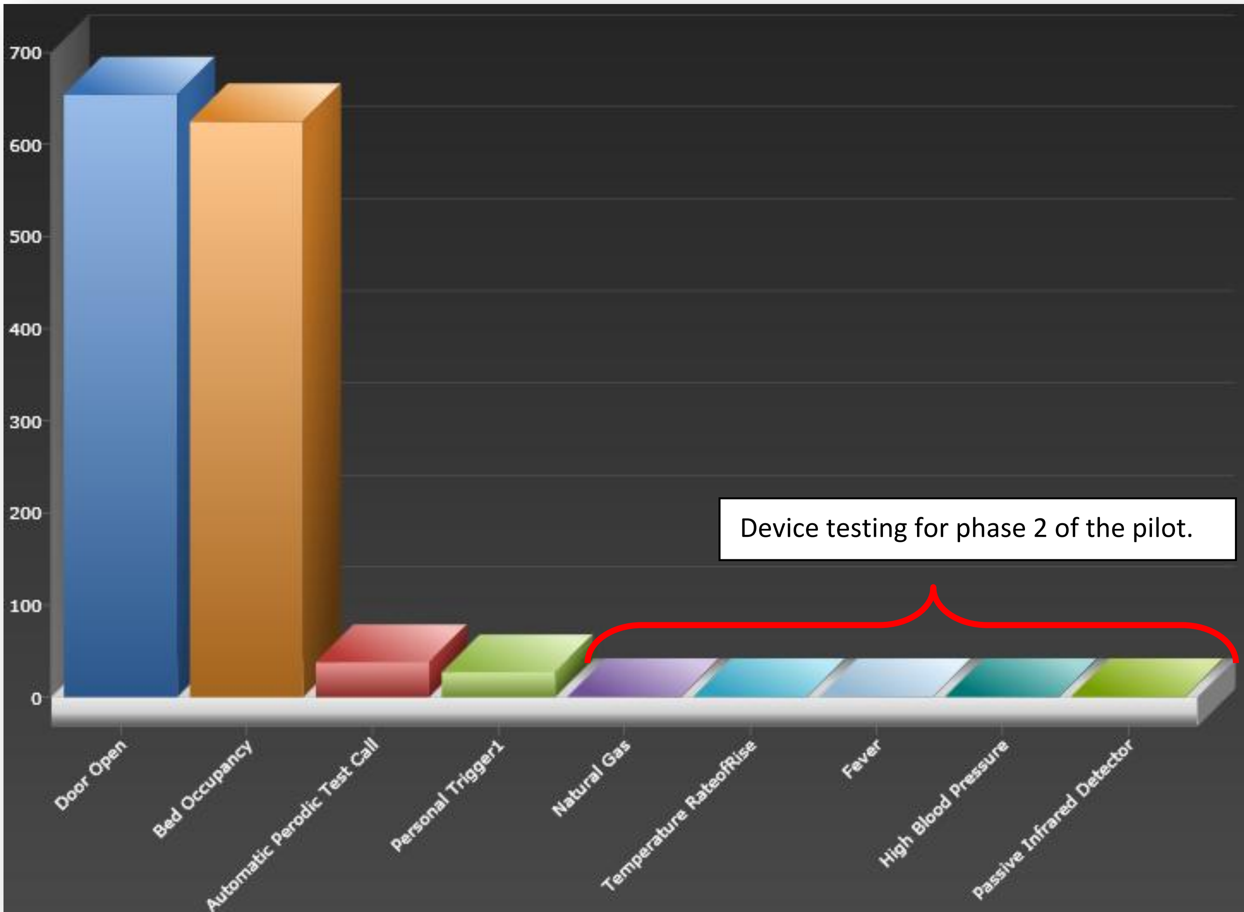


Figure 11

Results of the 'Bed Occupancy' sensors also showed us that Patient_Mary had some unrest on the 11th August. This patient had been getting in and out of bed a considerable amount of time from 22:06 – 23:10 on the 11th August 2010. In a Live environment this type of alert can be used to alert the clinician that the patient is unwell/uneasy.

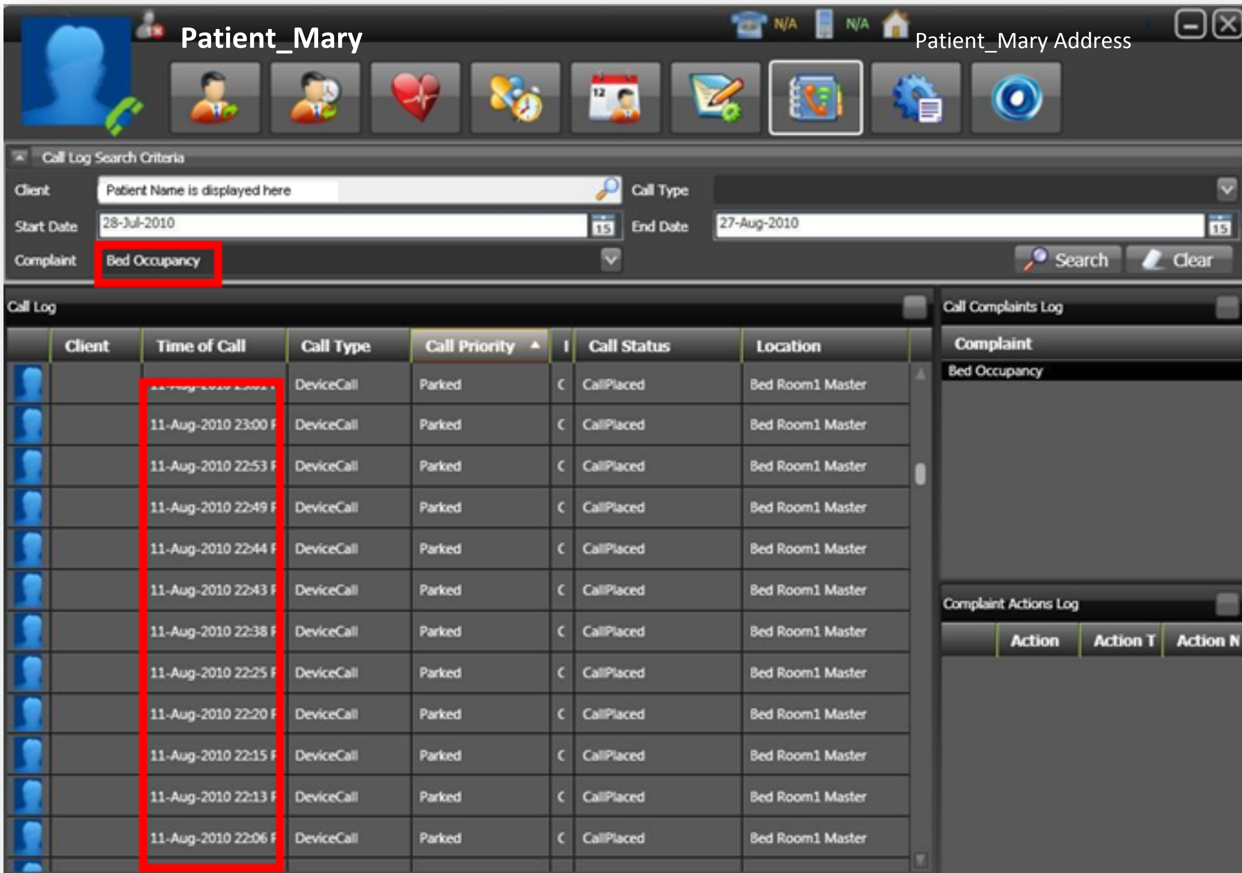


Figure 12

Figure 12 shows us the 'Bed Occupancy' alerts for Patient_Mary. The systems has flagged that there was abnormal behavior for this patient at 22:06 – 23:10 on the 11th August 2010.

Similar data for the other patients can be found in Appendix 9.

Conclusion

The results from this pilot showed that a Remote Monitoring System can be installed at patients home without the patient having to learn how to use a complex IT system. However as this type of system has worked well with Safety and Environment RPM system as no user interaction was required (unless the hit the panic button), however it might well be a different story for Health and Wellness as the user will be required to take their own readings and send the data to a PC.

Chapter 6 - Mobile Monitoring Application

Mobile Application

For the final part of my study I want to develop a RPM mobile application for Chronic Heart Failure patients. The application will be a working prototype.

This is how I envisage this working:

- A patient mobile phone device will be switched on, on start-up the RPMapp will automatically start
- At various point(s) throughout the day the patient will take their vital signs readings from a medical device
- The Medical device will automatically transmit the patient readings to the mobile phone and the RPMapp will interpret the vital signs readings
- The RPMapp will detect any abnormal readings and alert patients clinician and/or NOK via SMS and/or email
- The RPMapp will store the readings in mobile device
- All history of readings can be viewed by the patient/clinician
- On a specified day all the readings for that previous week can be emailed to the patients clinician

Introduction

Chronic heart failure (CHF) is a major cause of hospitalization in Western countries, with a high rate of re-admission (Zannad, Briancon, Juilliere, Mertes, Villemot, Alla, 1999)[94]. Despite effective therapies, patients with CHF suffer from a high rate of hospital re-admission and bear a high risk of death within the first months after an episode of acute heart failure (Solomon, Dobson, Pocock, Skali, McMurray, Granger, 2007).[95]

Patients suffering an episode of acute heart failure are at a high risk of adverse events within the first months after such an episode(Zannad, Briancon, Juilliere, Mertes, Villemot, Alla 1999)[96]. Reduction of re-admissions is a major goal in the management of CHF patients. Therefore, both the European and the American guidelines on CHF recommend disease management programs that include telephone follow-up or home nursing (Cardiol 2005).[97]

The case studies and research have shown how mobile phones can play an important role in helping older people and people with cognitive problems in many ways, especially with the increasing range of mobile phone-based applications and services on offer today.

Using GSM/3G Network in a Medical Environment

Mobile phone service providers have been delivering telecommunications and entertainment services for more than 100 years. As a result, they can leverage an established network infrastructure and customer relationships to ensure a successful RPM deployment.

Mobile phone technology (either GSM or 3G) is widespread in Europe and is a familiar tool, even in elderly patients. After 4 months of recruitment during the MOBIle Telemonitoring in Heart Failure Patients Pilot, MOBile amended the upper age limit for inclusion from 75 up to 80 years due to the ability of people to use Mobile phones within this age bracket.

Contrary to their expectations, data entry errors were rare, and the quality of self-reported data was appropriate for further clinical evaluation (Scherr, Kastner, Kollmann, Hallas, Auer, Krappinger, Schuchlenz, Stark, Grander, Jakl, Schreier, Fruhwald, FESC, 2008).[98]

IPhone

The platform I have decided to develop the application is for Apples Iphone. The main advantage I see on using the Iphone are as follows:

- It has 43% of internet usage on mobile phones indicating it’s the most popular mobile device for internet
- The user interface is very intuitive

- The app store is a major benefit for developing applications for the Iphone. A Remote Pateints Monitoring app can be put up on the app store for users to download globally. No installation charges, extra hardware charges etc required
- It can be used anywhere in the world (depending on the service provider), it can be taken with the patient while on holidays
- The application can run in the background un-noticed by the user
- It can be integrated with medical devices
- Reliable hardware with good battery life
- Has the ability to process, store and send data through SMS or GPRS using email or web services

Goal

The goal of this application is to achieve the following:

- The application I want to develop must be very simple for the user to use.
- It must use technology that is already in use by users.
- It must be very intuitive and easy to use.
- It must be easily accessible.
- It must be easily configurable.
- It must be cheap to use.
- It must detect high vital signs readings and alert NOK and clinicians.
- It must store previous readings which are easily accessed.
- It must alert NOK/Clinicans through technologies they already use for example email/sms.

Future developments

- Integration with medical devices – funding for this would be required as medical device hardware is required and also the suppliers SDK

Tools Checklist

After I had chosen the platform I want to develop my application for, the next step was to figure out how exactly I could do this, and more importantly was I capable of doing this. After some research I was able to come up with a 'Tools checklist' that I needed, these are as follows:

- Iphone Developer Program account – I needed to join the apple developer program to avail of their support services.
- IPhone – I needed an Iphone to test my application.
- Iphone SDK – I needed to download and install the latest version of the iPhone SDK from the developers account.
- Intel-based Mac computer with Mac OS X 10.5.5, after numerous failed attempts I uncovered that despite what technology forums say it is not possible to install the Mac OS onto a PC. The Iphone SDK cannot be installed on a Windows OS.
- Photoshop – I needed to install Photoshop on the Mac to create the images used in my application.
- Object C and Iphone SDK reference manual – I had to purchase an Object C reference book as there were no available in the university library.
- Tutorials and lecture classes on how to use the Iphone SDK effectively. Stamford University had an Iphone development course. The University recorded the lectures and made them available online, I downloaded the 24 classes.

Market Research

The next step was to do a bit of market research. I had to look at what other people are doing and what they have done. I downloaded various Health applications and other application onto my Iphone and tested these to see what worked and what didn't work.
Apps include:

- Glucose Buddy
- First Aid app
- iFitness
- RunKeeper
- HeartCheck
- BrainGame

Playing with other apps and reviewing the Apple Guidelines for UI design helped me to understand the capabilities of the iPhone and its interface.
I took a note of the following:

- How do well-designed apps navigate from screen to screen?
- How do they organise information?
- How much information to present to the user?
- How do they take advantage of the iPhone's unique characteristics: the accelerometer, swiping features, pinch, expand and rotate functions?

Screen Design

For the screen designs it was important that I sketched out what I wanted each page of the app to look like.
I asked myself:

- What information does each screen need to present?
- How can we take the user from point A to point B to point C?
- How should elements on the screen be proportioned or sized in relation to each other?

The apps goal is to allow a patient to easily and quickly enter their readings without having to use a complex user interface. For simplicity, I minimised the amount of screens and user interaction to enable the patient to quickly and easily enter their readings.

3 User screen are only required:

1. A screen is to allow the patient to add a note to a previous reading.
2. A screen to allow the patient to add a new reading
3. A screen to show the patient all their previous readings and to attach a note

Application Development

The next step was getting down to the development of my application. To do this I separated the development process into different modules, these are as follows:

- Settings File
- Data Storage
- Main Application
- Automatic system alerts
- Images

Settings File

I included a settings section to enable the user to enter patient specific data. The settings field is important as the application will need to know patient specific information to enable it to intelligently send to the patients Clinicians or/and NOK. The settings file captures the following information from the patient:

1. Patient current vital signs readings:
    - Systolic
    - Diastolic
    - Pulse
    - SA02
    - Weight

2. Patient NOK/Nurse/Consultant phone number. The phone numbers captured here will be used in the main application to send out automatic alert SMS if the patient readings are abnormally high.
    - Nurse phone number
    - NOK phone number
    - Consultant phone number

A blank value in the setting file for a phone number will indicate that no sms alerts are to be sent to that person.

3. Patient NOK/Nurse/Consultant email address. The email addresses captured here will be used to send an automatic email to the various users if abnormal readings are detected. Also at the end of the week an automatic email will be sent to the Nurse and Consultant with the patients readings for that week.

    - Nurse email
    - NOK email
    - Consultant email

A blank value in the setting file for an email address will indicate that no email alerts weekly readings are to be sent to that person.

Data Storage

To store the patient data on the device I wanted a reliable tried and tested storage mechanism, SQLite. SQLite is a software library that implements a self-contained, serverless, zero-configuration, transactional SQL database engine. SQLite is the most widely deployed SQL database engine in the world and it is ideal for my application.
I created my patient table in the terminal application on the Apple Mac. I then imported this into the application resource folder. I used the following to help me do this:

- SQLite reference manual
- SQLite forums

Main Application

I developed the main application using the Iphone SDK's Xcode development environment that is integrated with the Cocoa and Cocoa Touch frameworks for building Mac and iPhone apps. The development language that Xcode uses is Object C.

- Apple Dev Forum
- iPhoneSDK
- iPhoneSDKForum
- iPhoneDev Forums

- iPhoneSB
- Tutorials
- Reference books

A complete list of the commented source code is available in Appendix 8.

Automatic system alerts

There are various built in automatic alerts. When the user enters in an abnormal reading the application will automatically send an SMS/email to the values entered in the application settings file. There are 2 types of alerts included in this application:

- Blood pressure alerts
- Weight alerts

Blood pressure readings alerts

Blood pressure is typically recorded as two numbers, written as a ratio like this:

Systolic	117	Mm Hg
Diastolic	76	

This is read as '117 over 76 millimeters of mercury'. It should normally be less than 120/80 mm Hg (less than 120 systolic AND less than 80 diastolic) for an adult age 20 or over.
Systolic measures the pressure in the arteries when the heart beats (when the heart muscle contracts).
Diastolic measures the pressure in the arteries between heartbeats (when the heart muscle is resting between beats and refilling with blood).
(http://www.americanheart.org/presenter.jhtml?identifier=3025168).[99]

Figure 13 reflects blood pressure categories defined by the American Heart Association. I will use these values in my code to decide what readings will initiate an automatic alert to the NOK/Clinician. The right most column will shown if an alert will be sent to the clinicians/NOK

Blood Pressure	Systolic		Diastolic	Alert Generated

Blood Pressure Category	Systolic mm Hg (upper #)		Diastolic mm Hg (lower #)	Alert Generated
Normal	less than **120**	and	less than **80**	**No**
Prehypertension	**120 – 139**	or	**80 – 89**	**Email Clinician & NOK**
High Blood Pressure (Hypertension) **Stage 1**	**140 – 159**	or	**90 – 99**	**Email NOK & Clinician** **SMS NOK, Clinician**
High Blood Pressure (Hypertension) **Stage 2**	**160** or higher	or	**100** or higher	**Email NOK & Clinician** **SMS NOK & Clinician**
Hypertensive Crisis **(Emergency care**	Higher than **180**	or	Higher than **110**	**SMS NOK & Clinician** **Email NOK & Clinician**

Figure 8

Figure 13

(http://www.heart.org/HEARTORG/Conditions/HighBloodPressure/AboutHighBloodPressure/Understanding-Blood-Pressure-Readings_UCM_301764_Article.jsp)[100]

Also a BP alert will also be sent if:

- New Systolic reading is 10 mm Hg greater than the Patient Systolic reading in the setting file
- New Diastolic reading is 10 mm Hg greater than the Patient Diastolic in the setting file

Weight Alerts

It has been shown that the risk for re-hospitalization for worsening heart failure is highest in patient with weight gain of more than 4.5 kg within the week prior to hospitalization. Increasing body weight can also be used as an early warning sign of fluid retention and often signals worsening heart failure. If the patient weight increases by over 2 kg's an SMS will be sent to the NOK/Clinican. (Chaudhry , Wang, Concato, Gill, Krumholz. 2007)[101].

Images

I used Photoshop for all the creation/modification of the images I am using. The images for each reading in a row will be determined by the values entered in by the Patient. This will give the user a visual aid if all readings are OK or if there are high readings.

 Indicates the patients readings are OK.

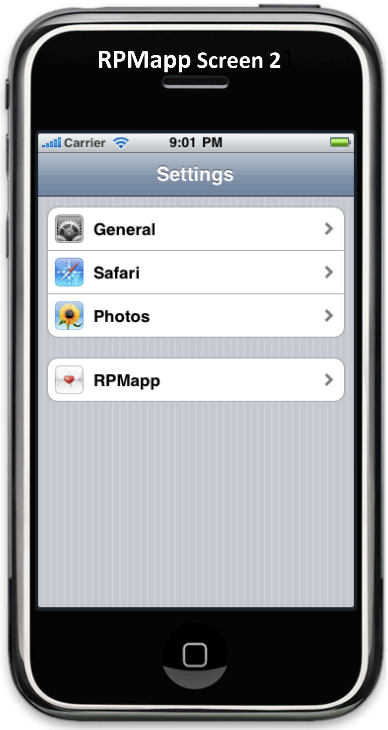
 Indicates prehypertension.

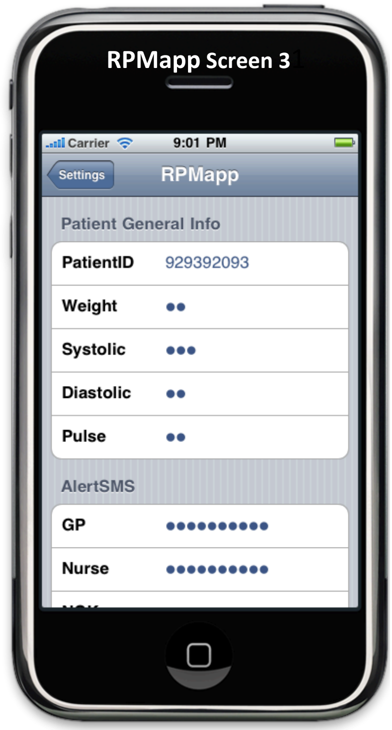
 Indicates High Blood Pressure stage 1 has been detected.

 Indicates High Blood Pressure stage 2 has been detected.

How the app works.

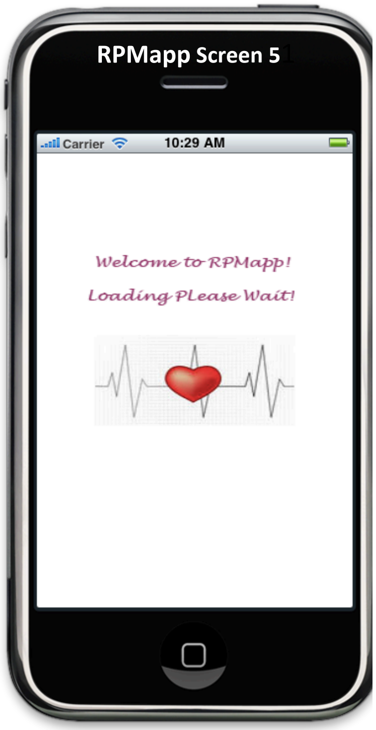
First the user will download the app from the app store (when it is released). When the app has successfully downloaded you should see the RPMapp icon on your phone, please see RPMApp Screen 4. An RPMapp settings file will appear in the Iphone settings section. The patient/family member/clinician will enter in the patient specific details in the settings file. Please see RPMapp Screen 1, RPMapp Screen 2 and RPMapp Screen 3 below. The settings will only need to be entered once.

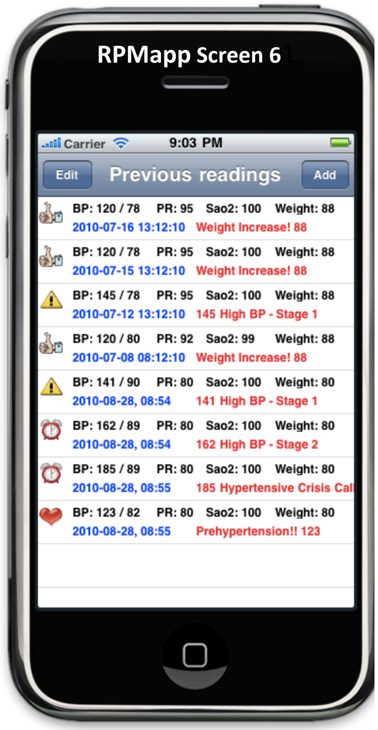




Patient specific information, GP, Nurse and NOK phone numbers and email addresses are all password blocked so a malicious user cannot see the value in these.

When the settings have been entered into the RPMapp settings file, the user can start to enter their readings on a daily basis. There will be an RPMapp icon on the patients Iphone (Please see RPMapp Screen 4) and when the user taps on the icon (as they would do on any app), the RPMapp will open onto the main screen (RPMapp Screen 6). It is worth noting here that the first time the app is run there will loading up screen appear for a few seconds. This will only happen the first time the app is run as the SQLite database will be created and this takes a few seconds. Please see RPMapp Screen 5.

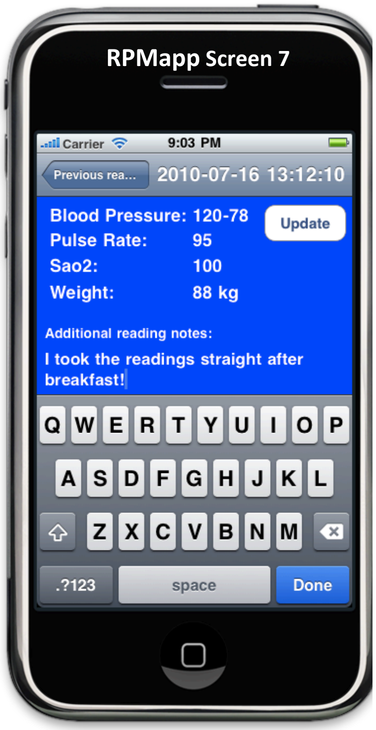


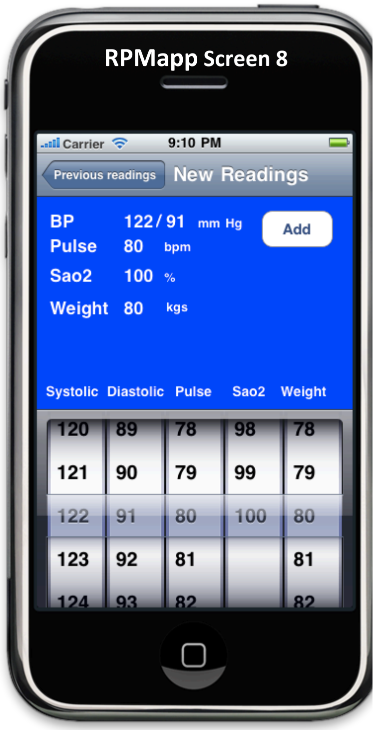


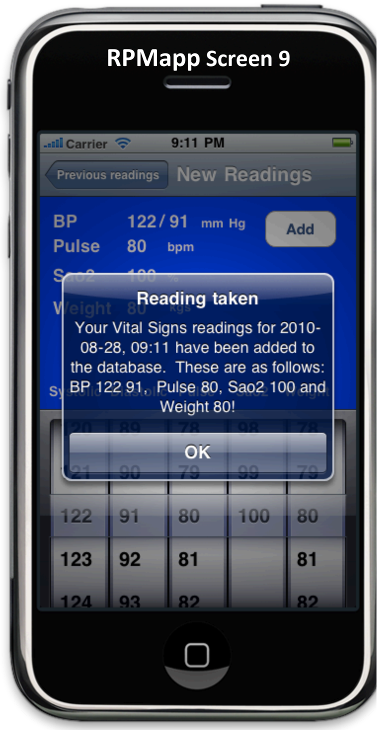
From the main screen the user can ‘Add’ a new reading or leave a note for a previous reading. To leave a note the user will click on the reading row and a new screen will open - RPMapp Screen 7. The user can leave a note and will select the ‘Update’ button. The note will be attached to this particular reading and will be saved on the database.

To add a new reading the user will click the ‘Add’ button. A new screen will appear - RPMapp Screen 8. They will select each reading value using the picker on screen – pickers have proved to be a lot more accurate and a lot quicker than using a free text field. After they have entered their readings they will hit the ‘Add’ button. A message will appear to let the user know that the new readings have been added to the database - RPMapp Screen 9. The new reading will now appear on the main menu screen. At this point the system will check the values of the readings and if the readings are high an automatic sms/email will be sent to the selected parties – please see the alert section on page 74 and 75 of this document. RPMapp Screen 10 and 11 s

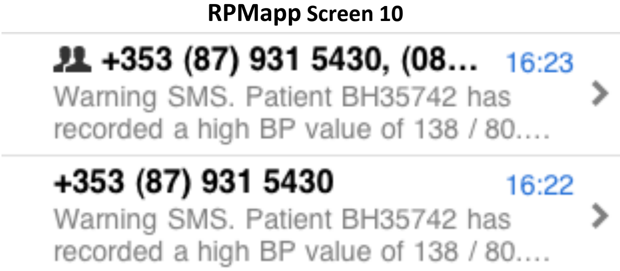
At the end of the week all the patients readings for that week are emailed to the clinicians to review.



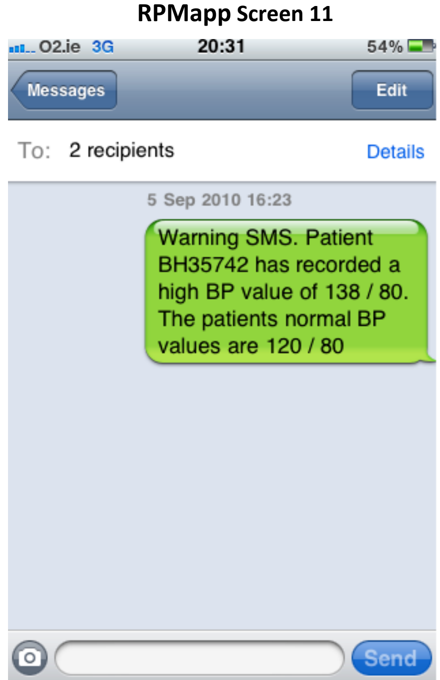




RPMapp Screen 10



RPMapp Screen 11



Above in ‘RPMapp Screen 10 & 11’ we can see an automatic has been sent to the clinician & NOK. This SMS Alert will notify the clinician & NOK that the patient BP has increased from 120/80 to 138/80.

Application Benefits

- Easy To Use - No computer skills required, uses standard Iphone technology
- Convenient - Patients monitor themselves just as they always have, with no added complexity.
- Secure- The system transmits data safely and securely over private phone lines.
- Affordable – Free from Itunes
- Accuracy and quick data entry. Using the picker element it prevents typo errors. The unit automatically forwards data and records the time and date of all measurements, dramatically reducing the possibility of human error.
- Customisable – it can be easily customized to accommodate a variety of input devices, making it ideal for clinical trials.
- Portable - Battery power gives users the freedom to travel and the ability to transmit their data from virtually any location
- Flexible - You decide what data to monitor
- The system infrastructure is based on existing telecommunication networks, requires no knowledge of 'Hi Tech' computing and can be accessed by clinicians by using existing email account and SMS messaging. No other username, password, software or URL's required for clinician to remember.

Limitations of my Design

Although my app is not designed to include patients with visual impairment, a promising solution could be the use of near field communication (NFC) in RPM technology. Unlike Bluetooth, NFC supports a touch-based method for data acquisition using upcoming NFC-enabled mobile phones. In addition to data acquisition from medical devices, it provides access to data stored on radio frequency identification (RFID) tags (eg, electronic barcodes), which could be embedded in future telemonitoring technology. (Chaudhry , Wang, Concato, Gill, Krumholz. 2007)[102]

Future Modifications

- Integration with Medical devices so very limited user interaction is required
- Generation of XML/HL7 for Vital Signs readings so data can be uploaded to EHR's through web services
- Upgrades in Iphone hardware with faster processor and greater battery life
- Improve application for visual impaired patients using NFC

Is Software Classified as a Medical Device?

The European Directive 2007/47/EC, which came into force on 21 March 2010, requires for the first time that certain software be classified as medical devices and validated and CE-marked accordingly. The new rules are incorporated in the directive in the form of amendments to the existing directive on medical devices[103] (the MDD) and the current directive on active implantable medical devices (the AIMDD) (Directive 90/385/EEC, OJ, 20 July 1990, L189, 17-36, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31990L0385:EN:HTML) [104].

Software engineering has advanced considerably and technology is becoming an increasingly common feature of medical devices, these amendments are designed to recognize this and the fact that software can be subject to safety risks.

Only certain types of medical related software are covered by the amended rules. Software is considered a medical device if it meets one or more of four criteria:

1. the software's intended purpose satisfies one of the purposes explicitly mentioned in Article 1, paragraph 2(a) of the MDD or AIMDD, for example software used for diagnosis, monitoring, treatment or alleviation;
2. the software's purpose is to control or influence the functioning of a medical device within the meaning of the MDD or the AIMDD. An example here would be software that takes over the dose-planning function of a medical device;

3. the software is used for the analysis of patient data generated by a medical device, with a view towards diagnosis and monitoring. Examples here are software used to process image data from X-ray scanners or for analysing data collected from long-term electrocardiogram monitors; or
4. the software is designed to be used for, or by, patients in the diagnosis or treatment of a physical disease or mental health condition. (*Mathias, Klümper and Vollebregt. 2009)*

Due to this it is important to note that the RPMapp is not classified as a medical device. The RPMapp is only used for reference or to quickly alert a clinician or patient NOK for worsening condition.[105]

Software classifications and the applicability of the amended MDD and AIMDD		
Software	**Amended directives**	**CE-marking**
A medical device itself or an accessory to a medical device	Directly applicable to software	CE-marking required for software
A component and integral part of medical device	Not directly applicable to software	CE-marking not required for software. Software must be covered by conformity assessment of the medical device
Neither a medical device, accessory thereto, nor a component	Not applicable	No CE-marking required

[106]

Figure 9 Mathias, Klümper and Vollebregt. 2009

Chapter 7 - Conclusion

Conclusion

Can Remote Patient Monitoring ease the massive burden on current healthcare system?
Is it a viable solution to deal with ageing baby boomers crisis? Can mobile phone technology be used as the service delivery platform for Remote Patient Monitoring?

With increased consumption of health care services, increase in chronic diseases and conflicts and emergence of new diseases are placing additional demands on a health workforce. Conflict often also causes severe and long-lasting damage to the health workforce itself (WHO 2006).[107] Population growth, ageing population and advancement in technologies are other factors increasing the demand of health workforce (Domunt, Zurn 2002).[108]

Huge challenge is to create awareness about Chronic Diseases among patients, their families, and general public and even doctors for the seriousness of the chronic diseases and spread education about. This research shows that Remote Patient Monitoring is highly cost effective and reliable solution for monitoring Chronic Disease. The challenge, however, is to translate the successful pilot experiences into financially sustainable, widely adopted care processes.

Despite the increasing acceptance of RPM, there are a few issues that need to be addressed that hold back the adoption of RPM systems. For example the high price of RPM acts as a deterrent to its adoption. Adoption of RPM technology would not significantly increase unless prices are reduced. Mobile phone technology is can be a major player here, most people even the elderly carry mobile technology that is capable of processing monitoring data and transmitting it to the clinician. This research has shown this possibility to be very real.

If above challenges can be addressed, huge business opportunity is waiting to be harnessed.

Bottom Line

Who should pay?

Health plans and other payers? doctors? patients? disease management companies? home health agencies? someone else?(Kuraitis 2007)[109]

Appendix 1 - Medical Devices required for monitoring various diseases

Category	**Examples of Diseases**	**Medical Devices**
Heart	Arrhythmia, Post Operative Monitoring, Heart insufficiency / heart failure	Pulse Oximeter, ECG 3 Lead Monitor, Body weight Scale, Blood Pressure
Lifestyle	Physical Exercise, Wellbeing Programmes, Obesity, Smoke Cessation	Pulse Oximeter, ECG 1 Lead Monitor, Body Weight Scale
Diabetes (Chronic)	Diabetes, Risk diabetes patients	Glucometer, Blood Pressure Monitor, Body weight scales
Chronic Diseases	COPD, Asthma, Emphysema (Lung disease caused by smoking), Sleep Apnoea, Prolonged Pain Treatment, Post Operative Pain, Cancer Pain, Elderly Pain, Prematurely born infants, Pediatric malformations (heart)	Pulse Oximeter, Capnography, PEF meter, Body weight scales
Warfarin* treated patients (Warfarin is used to prevent blood clots from forming or growing larger)	Myocardial Infraction, Atrial fibrillation, Transplant surgery patients, Heart valve replacement patients.	Coagulation Monitor

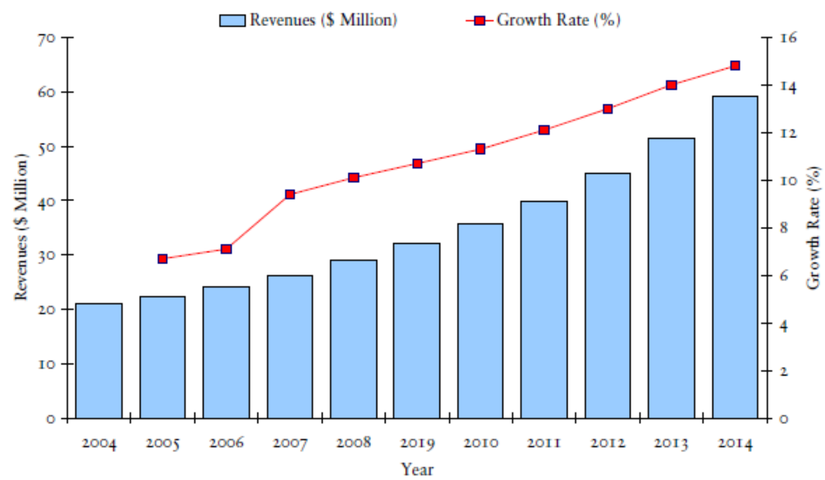
Source: Healthservice24, Telus Websites

http://interactware.com/2010/08/18/white-paper-on-mobile-health-monitoring/

Appendix 2 Market

France

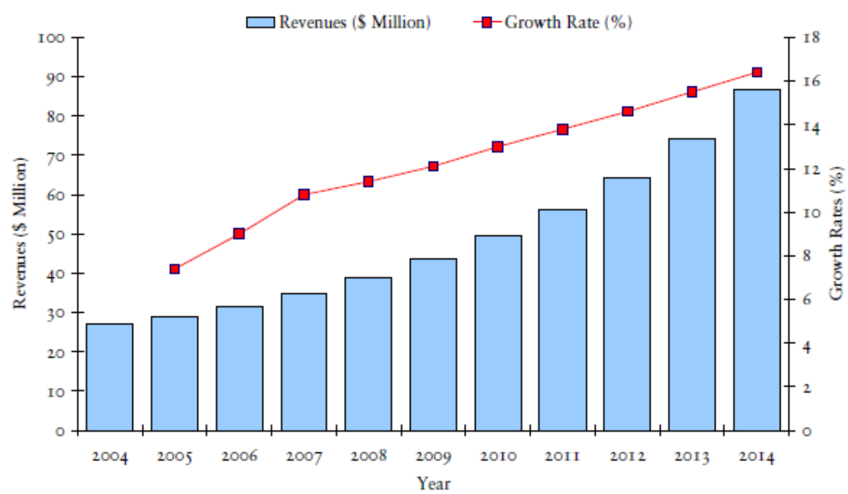
Remote Patient Monitoring Market: Revenue Forecasts (France), 2004-2014



Note: All figures are rounded; the base year is 2007. Source: Frost & Sullivan 110

Germany

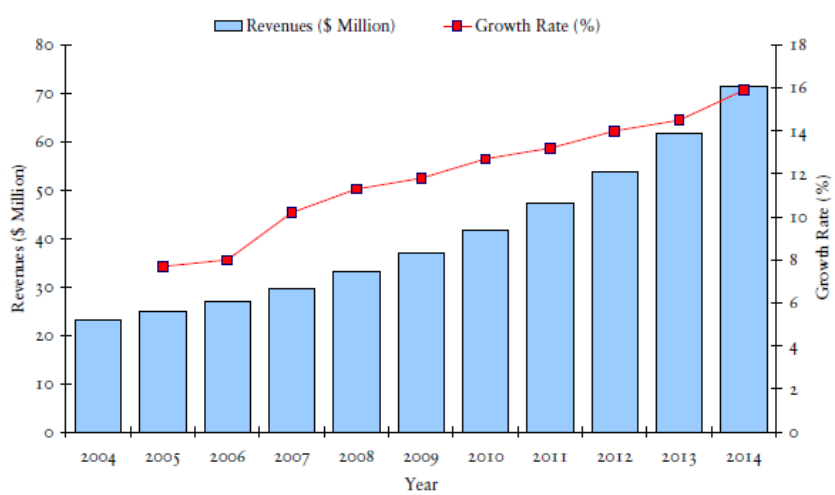
Remote Patient Monitoring Market: Revenue Forecasts (Germany), 2004-2014



Note: All figures are rounded: the base year is 2007. Source: Frost & Sullivan 111

Italy

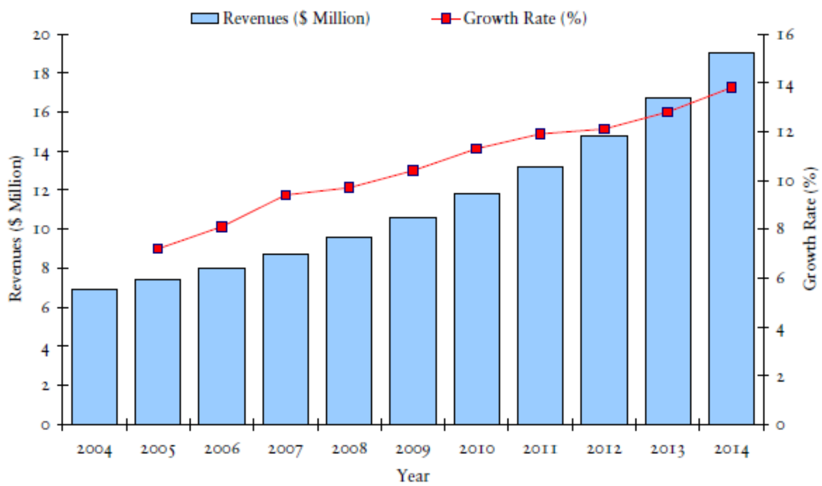
Remote Patient Monitoring Market: Revenue Forecasts (Italy), 2004-2014



Note: All figures are rounded; the base year is 2007. Source: Frost & Sullivan 112

Spain

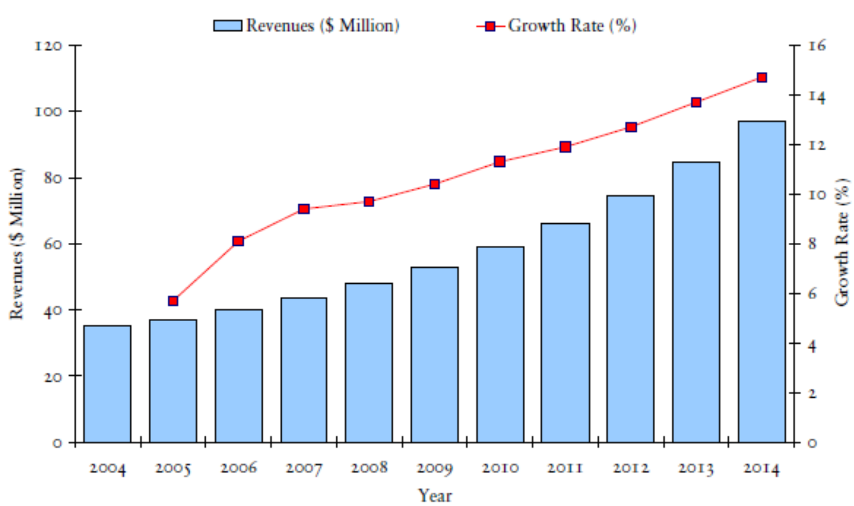
Remote Patient Monitoring Market: Revenue Forecasts (Spain), 2004-2014



Note: All figures are rounded; the base year is 2007. Source: Frost & Sullivan 113

UK

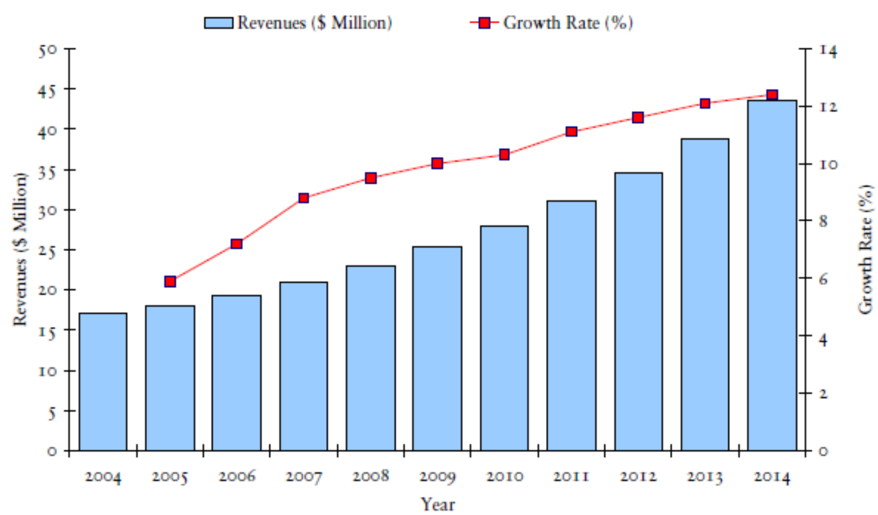
Remote Patient Monitoring Market: Revenue Forecasts (United Kingdom), 2004-2014



Note: All figures are rounded; the base year is 2007. Source: Frost & Sullivan 114

Benelux

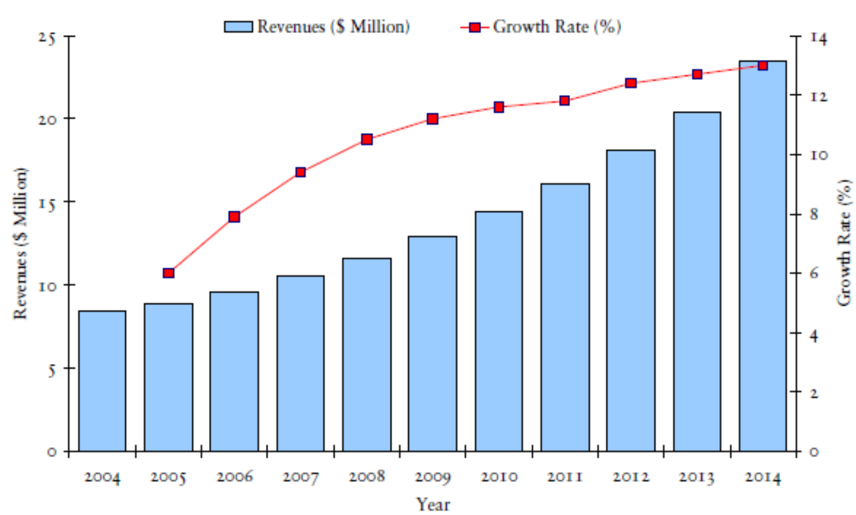
Remote Patient Monitoring Market: Revenue Forecasts (Benelux), 2004-2014



Note: All figures are rounded; the base year is 2007. Source: Frost & Sullivan [115]

Scandinavia

Remote Patient Monitoring Market: Revenue Forecasts (Scandinavia), 2004-2014



Note: All figures are rounded; the base year is 2007. Source: Frost & Sullivan [116]

Appendix 3 - Canadian Case Study with Black Berry

I have included this case study to show that cost effective mobile phone based RPM solutions have been successfully deployed.

In a Canadian government funded trial, UHN (University Health Network) and Mount Sinai Hospital investigated various home tele-monitoring systems for Type II Diabetes patients. Most systems were dismissed because they required a technically savvy user and cost too much since an operator was needed as the interface between the patient and healthcare provider. In a 33-patient trial for Type II Diabetes, conducted in 2006, BlackBerry smartphones emerged as a viable alternative; the solution showed it could increase patient involvement in their own healthcare, without adding more pressure to the healthcare system.

The UHN trial involved 33 patients and 25 physicians. Each patient was supplied with a Bluetooth-enabled blood pressure monitor, a glucometer to measure blood sugar, and a BlackBerry smartphone provisioned for, and managed using, UHN's.

UHN's IT team wrote a Java application for the BlackBerry smartphone that "listens" for the Bluetooth signal sent from the blood pressure cuff once a reading is taken. When a patient monitors blood sugar, they are prompted by a text message on the screen of the BlackBerry smartphone to choose whether readings were taken before or after a meal.

The team then built a database in SQL. It includes a series of decisions and rules that interpret the readings based on a specific range of blood pressure or blood sugar levels. For example, if a person's readings over the past several days are above or below the thresholds set by their physician, the built-in alerting system of the application kicks in.

A text message appears on the BlackBerry screen with advisory message for the patient to watch their levels more closely (See Figure 1). Doctors for each of the patients receive the readings according to default rules set up by the physicians, so not every reading is sent, but rather trends. If a reading is cause for alarm, a doctor would be immediately notified.

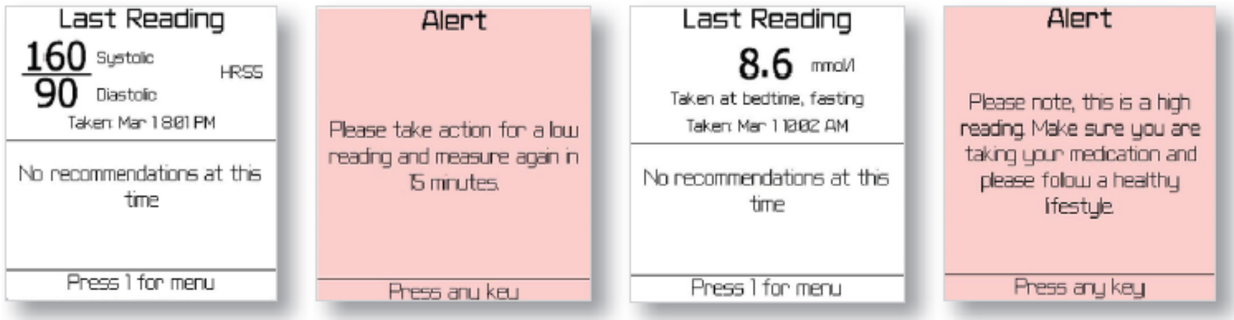


Figure 1 – Sample blood sugar and blood pressure readings and alert screens

Results

Cost-effective Solution: In an era of high-cost healthcare and diminishing services, home-based monitoring using BlackBerry smart phones in this study proved to be 10 times less expensive than estimates for other remote monitoring solutions.

Secure Way to Transmit Patient Data: The BlackBerry Enterprise Solution met UHN's strict privacy standards for health institutions sending patient information over-the-air.
Simplified Development: The BlackBerry Enterprise Solution is a comprehensive development environment that offers coding, testing and deployment in one package.

Flexibility and Control with Applications: UHN's design team was able to control how many features were available to users, set up rules that remotely monitored readings and automatically send out alerts and report finding to doctors with the frequency they wanted – all because of the BlackBerry Java Development environment.

Just the Beginning: Because patients were comfortable monitoring their own vital signs, they performed the tasks more regularly. As a result, improvements in health outcomes were achieved and the trial broke new ground, promising even more patient self-management solutions.
In the pilot study, 24-h ambulatory BP fell by 11/5 mm Hg, and BP control improved significantly. Substantially more home readings were received by the server than expected, based on the preset monitoring schedule. Of 42 BP alerts sent to patients, almost half (n 20) were due to low BP. Physicians received no critical BP alerts. Patients perceived the system as acceptable and effective.[117]

Appendix 4 - World-First Full-Scale Clinical RCT with High-Risk Patients

The annual risk of a patient with heart failure being admitted to hospital is about 40%, with worsening of heart failure the predominant cause[118]. Admission to hospital with an episode of worsening heart failure predicts a high risk of recurrent events and death.

Heart failure is costly to manage, consuming between 1-2% of all health system costs in developed countries, and about 70% of costs are due to hospital admissions.[119]

The aim of the TEN-HMS (homecare management system) project was to scientifically test whether RPM can improve medical outcome for the heart failure patients as well as their quality of life and the efficiency of healthcare processes. The feasibility of such a trial as well as the usability and reliability of the technical equipment had been examined in the pilot.

For this prospective randomized controlled clinical trial, 426 patients with a recent exacerbation of chronic heart failure were selected. University and regional hospitals in Germany, the Netherlands, and the UK as well as local specialists and GPs were involved. By a random selection process, guided and controlled by an outside specialized institute, patients were allocated at a 1:2:2 to one control and two intervention groups:

1. The Usual Care (UC) group comprised 85 patients: The primary care physician was responsible for implementing the patient management plan with usual support provided by the GP.
2. The Nurse Telephone (NT) group comprised 173 patients: The primary care physician was responsible for implementing the patient management plan, plus additional monthly telephone contracts from a heart failure nurse to help increase effectiveness and adherence.
3. The Telemonitoring (TM) group comprised 168 patients: A heart failure nurse or physician was primary responsible for implementation of the patient management plan. Ongoing support was provided by twice-daily Telemonitoring of vital signs (vital data [weight, blood pressure and pulse, rhythm] using home monitoring equipment interfaced automatically through cordless communication with the telephone; data were transmitted through secure networks to a medical service center)

Standard best care is well understood for heart failure patients, therefore the UC group was smaller to improve the overall efficiency of this costly trial. – To allow for comparable results across different countries and health systems and to secure methodological rigor, strict patient selection criteria were established. It is estimated that up to 20% of patients with heart failure fulfill the entry criteria set.

Patient recruitment started in June 200 and continued until March 2002. Collection of patient follow-up data ended in November 2002, data was obtained for more than 205,000 patient-days for analysis.

For methodological reasons, particularly so as not to influence the behavior of the physicians and nurse participating, no interim results were made available.

Results

The data obtained indicate that the heart failure patients supported by telecare, either via monthly telephone calls or monitoring, have indeed a substantially and significantly lower mortality rate compared to patients obtaining usual care (best medical practice based on a patient management plan). E.g. at 360 days follow up, the usual care group lived on average, about 263 days, compared with 307 days for the nurse telephone and 303 days for the telemonitoring group.

The number of admissions into hospital were slightly higher for the TM group than for NT group, but the mean duration per admission were considerably lower, up to 25%. Overall, the total days in hospital were considerably and consistently lower for the TM group.

Further data analysis indicate that the cost saving of the overall reduction in hospital bed-days more than offsets the increased cost of telemonitoring compared to nurse telephone monitoring. Nearly all (90%) of telemonitoring patients were very enthusiastic about this kind of support, stating that they felt much safer regarding their health management.

The TEN-HMS project was the first large (426 patients), long-term (240 to more than 600 days of follow-up) randomized controlled trial of telemonitoring for heart failure patients. The data suggest that increased patient support by some form of telecare can significantly improve the survival rate of high-risk patient support by some form of telecare can significantly improve the survival rate of high-risk heart failure patients. It is interesting to note that regular telephone contact and support may lead to a significant improvement in *days alive and out of hospital* and that compared to nurse-telephone support, telemonitoring may lead to a further improvement.

The slightly higher admission rate for the TM group indicates that closer surveillance may lead to an earlier, but perhaps more timely detection of a worsening health status. This may also explain the significantly lower mean duration per admission.
The initial results of this world wide unique study provide a strong argument for the wider introduction of telecare. Considering the significantly improved survival rate of high risk patients supported in this way it becomes an ethical imperative to improve the organisation of the delivery of healthcare to patients with heart failure.[120]

Appendix 5 - MOBIle Telemonitoring in Heart Failure Patients

The goal of the MOBIle TELemonitoring in Heart Failure Patients Study (MOBITEL) was to evaluate the impact of home-based telemonitoring using Internet and mobile phone technology on the outcome of heart failure patients after an episode of acute decompensation.

The recruitment for this study started on October 1, 2003, and was closed with the sign-off of the last patient on April 29, 2008. Local regulatory authorities approved the study, with the University Clinic Graz being the lead ethics committee.

Patients were randomly allocated to pharmacological treatment (control group) or to pharmacological treatment with telemedical surveillance for 6 months (tele group). The adaptive randomization procedure was arranged by patient age, New York Heart Association (NYHA) class, gender, and study center. Please see Appendix 1 for NYHA classifications.

Patients randomized into the tele group were equipped with mobile phone–based patient terminals for data acquisition and data transmission to the monitoring center.
The telemonitoring equipment consisted of three commercially available components:

1. a Nokia 3510 mobile phone
2. a weight scale with 0.1 kg accuracy and electronic display
3. a sphygmomanometer for fully automated measurement of blood pressure and heart rate

The tele group patients were trained on using the mobile phone and how to take measurement of blood pressure and weight using the equipment.

Tele group patients were asked to measure vital parameters (blood pressure, heart rate, body weight) on a daily basis at the same time, preferably in the morning after emptying the bladder and before dressing and taking medication.

Study physicians had continuous access to the data via a secure Web portal. If transmitted values went outside individually adjustable borders, study physicians were sent an email alert. Primary endpoint was hospitalization for worsening CHF or death from cardiovascular cause.
Baseline demographics and medication were recorded for all patients, and an appointment for the 6-month follow-up was made. There was no planned interaction between study site and patients in the control group within the follow-up period of 6 months. Patients in the tele group were given the telemonitoring equipment and an appointment for telephone or face-to-face technical training.

Physicians were advised to use the automated warning system for the monitoring of vital parameters of their patients. If transmitted values went outside individually adjustable borders, study physicians were sent an email alert. Additionally, an email alert was generated if a patients body weight increased or decreased more than 2 kg in 2 days. After receiving an alert, study physicians could contact the patient directly via the mobile phone to confirm the parameters and, if appropriate, could ask the patient to adjust his or her medication.

For technical questions, patients had access to a 24-hour hotline at the service center
The control group comprised 54 patients (39 male, 15 female) with a median age of 67 years (IQR 61-72), and the tele group included 54 patients (40 male, 14 female) with a median age of 65 years (IQR 62-72). There was no significant difference between groups with regard to baseline characteristics.

Results

The combined primary endpoint of this study was cardiovascular mortality or re-hospitalization for worsening heart failure. Besides evaluation of patients' functional status according to the NYHA classification and length of stay during re-hospitalizations, further secondary endpoints focused on technical parameters: system availability, cumulative transmissions, and transmissions per patient.
Study patients were classified as reaching the primary endpoint in case of hospital admission for worsening heart failure or cardiovascular death within the study period.

- Twelve tele group patients were unable to begin data transmission due to the inability of these patients to properly operate the mobile phone ("never beginners").
- Four patients did not finish the study due to personal reasons.

- Intention-to-treat analysis at study end indicated that 18 control group patients (33%) reached the primary endpoint (1 death, 17 hospitalizations), compared with 11 tele group patients (17%, 0 deaths, 11 hospitalizations; relative risk reduction 50%).
- Per-protocol analysis revealed that 15% of tele group patients (0 deaths, 8 hospitalizations) reached the primary endpoint (relative risk reduction 54%, 95% CI 7-79%, *P*= .04).
- NYHA class improved by one class in tele group patients only.
- Tele group patients who were hospitalized for worsening heart failure during the study had a significantly shorter length of stay (median 6.5 days, IQR 5.5-8.3) compared with control group patients (median 10.0 days, IQR 7.0-13.0; *P*= .04).
- The event rate of never beginners was not higher than the event rate of control group patients.

The study was stopped after randomization of 120 patients (85 male, 35 female); median age was 66 years (IQR 62-72). [121]

Appendix 6 - Environment Assessments

Patient_Mary Home Assessment

Patient_Mary is an elderly lady living alone. She was recently diagnosed with Diabetes. She has a carer visit Monday to Friday from 10:00 to 13:00 with family members at weekends. No history of falls, however new medication may increase likelihood of falls. No history of wandering. She has used pendant alarm in the past but no longer uses it although has been advised to by consultant.

Living situation

Patient has a two storey house with both the bedroom and main bathroom located upstairs. There is a large rear garden with steps to a raised grass area. Patient has a small front garden with no notable hazards. Patient rarely visit raised grass area without supervision.

Patient is quite active and does not have a settled life style, for example she goes to family member's house quite regularly to baby sit or to stay overnight. She regularly goes to church nearly on a daily basis especially around religious holidays like Christmas and Easter.

Suggestions

- Back door – Door sensor
- Front door – Door sensor

Living room

The living room is located at the front of the house. Patient spends time here daily reading the news paper in the morning and watching television some evenings.

Suggestions

- Chair sensor on armchair
- Fall detector
- Door sensor

Kitchen

The kitchen is located towards the back of the house. The meals are usually prepared by carer, the patient spends quite a bit of time here listening to radio and on telephone.

Suggestions

- Door sensor
- Motion detector on kitchen entrance
- Smoke alarm

Bathroom

The bathroom is located upstairs by the bedroom. It has an accessible shower.

Suggestions

- Ceiling pull chord switch between shower and toilet, reachable from both.
- Door sensor
- Weight scale

Bedroom

The patient has a telephone at bedside, she uses an electric blanket.

Suggestions

- Bed sensor
- Door sensor
- Bed panic button
- Fall detector

Hall

- Motion detectors
- Co2 detector
- Smoke alarm in the hall
- Fall detector at foot of stairs.

Other

Patient should be provided with a wearable panic button.

Patient_John Home Assessment

Patient_John is an elderly man living with his elderly wife, he is a CHF patient. His wife is generally in good health but needs assistant to care for Patient_John. They have a carer visit daily from 11:00 to 13:00 with family members at evenings and weekends. Patient_John has a history of falls; he fell while gardening a few years back and needed a hip replacement. He also fell over in the house a few times but no notable injuries. He needs the assistance of a walking stick. His wife is quite active and Patient_John could spend a few hours a day alone at home.

Living situation

Patient has a two storey house with both the bedroom and main bathroom located upstairs. There is a rear garden with grassed area. Patient has a large front garden with no notable hazards. Patient spends some time in the rear garden doing light gardening work – watering plants etc.

Patient is quite active and does not have a settled life style. He visits the local pub daily for a pint and he is a frequent visitor of the local GAA club.

Suggestions

- Back door – Door sensor
- Front door – Door sensor

Living room

The living room is located at the front of the house. Patient spends time here daily reading the news paper in the morning and watching television in evenings.

Suggestions

- Chair sensor on armchair
- Fall detector
- Door sensor

Kitchen

The kitchen is located towards the back of the house. The meals are usually prepared by his wife or sometimes the carer.

Suggestions

- Door sensor
- Fall detector
- Motion detector on kitchen entrance
- Smoke alarm

Bathroom

The bathroom is located upstairs opposite the bedroom. It has an accessible shower.

Suggestions

- Ceiling pull chord switch between shower and toilet, reachable from both.
- Door sensor
- Weight scale

Bedroom

The main bedroom has a large double bed and built in wardrobes.

Suggestions

- Bed sensor
- Door sensor
- Bed panic button
- Fall detector

Hall

- Motion detectors
- Co2 detector
- Smoke alarm in the hall

- Fall detector at foot of stairs.

Other

Patient should be provided with a wearable panic button.

Patient_Agnus Home Assessment

Patient_Agnus is an elderly lady living alone, she is a CHF patient. She has a carer visit Monday to Friday from 11:00 to 13:00 with a daughter who visits often. She has a history of falls but no severe injuries. She was given a panic alarm but resisted in using it.

Living situation

Patient has a small bungalow with a bedroom and 2 bedrooms. There is a small rear garden with a grassed area, there is no front garden. The step into the house is quite large for a step.
Patient is quite active and does not have a settled life style. She visits elderly neighbor nearly daily and is a frequent visit to the local market. She also goes to Bingo twice a week.
Suggestions

- Back door – Door sensor
- Front door – Door sensor

Living room

The living room is located at the front of the house. Patient spends some time watching TV and reading newspaper. The phone is home phone is located here.
Suggestions

- Chair sensor on armchair
- Fall detector
- Door sensor

Kitchen

The kitchen is located towards the back of the house. The patient lunch is usually prepared by carer. There is a TV located here also and the patient spends time here in the evening watching TV.

Suggestions

- Door sensor
- Motion detector on kitchen entrance
- Smoke alarm

Bathroom

The bathroom is located directly opposite the bedroom. It has an accessible shower.

Suggestions

- Ceiling pull chord switch between shower and toilet, reachable from both.
- Door sensor
- Weight scale

Bedroom

The patient has a telephone at bedside.

Suggestions

- Bed sensor
- Door sensor
- Bed panic button
- Fall detector

Hall

- Motion detectors
- Co2 detector
- Smoke alarm in the hall
- Fall detector at foot of stairs.

Other

Patient should be provided with a wearable panic button.

Patient_John Home Assessment

Patient_John is an elderly man living his own. He has no carer with family members visiting some evening and at weekends. Patient_John has a history of falls; he was quite active cyclist until a few years back he fell off his bike and damaged his knee. He also fell over in the house a few times after the accident but no notable injuries. Patient_John was diagnoses with Diabetes last year.

Living situation

Patient has a two storey house with both the bedroom and main bathroom located upstairs. There is a rear garden with grassed area. Patient has a large front garden with a parking area where he parks his car. Patient spends some time in the rear garden doing light gardening work – watering plants and in the front garden looking after his car.

Patient is quite active and does not have a settled life style. Patient visits the local pub once twice weekly in the evening time with a friend. Patient regularly visits elderly brother and other family members.

Suggestions

- Back door – Door sensor
- Front door – Door sensor

Living room

The living room is located at the front of the house. Patient spends time here daily reading the news paper in the morning and watching television in evenings.

Suggestions

- Chair sensor on armchair
- Fall detector
- Door sensor

Kitchen

The kitchen is located towards the back of the house. The meals are usually prepared by his wife or sometimes the carer.

Suggestions

- Door sensor
- Fall detector
- Motion detector on kitchen entrance
- Smoke alarm

Bathroom

The bathroom is located upstairs opposite the bedroom. It has an accessible shower.

Suggestions

- Ceiling pull chord switch between shower and toilet, reachable from both.
- Door sensor
- Weight scale

Bedroom

The main bedroom has a large double bed and built in wardrobes.

Suggestions

- Bed sensor
- Door sensor
- Bed panic button
- Fall detector

Hall

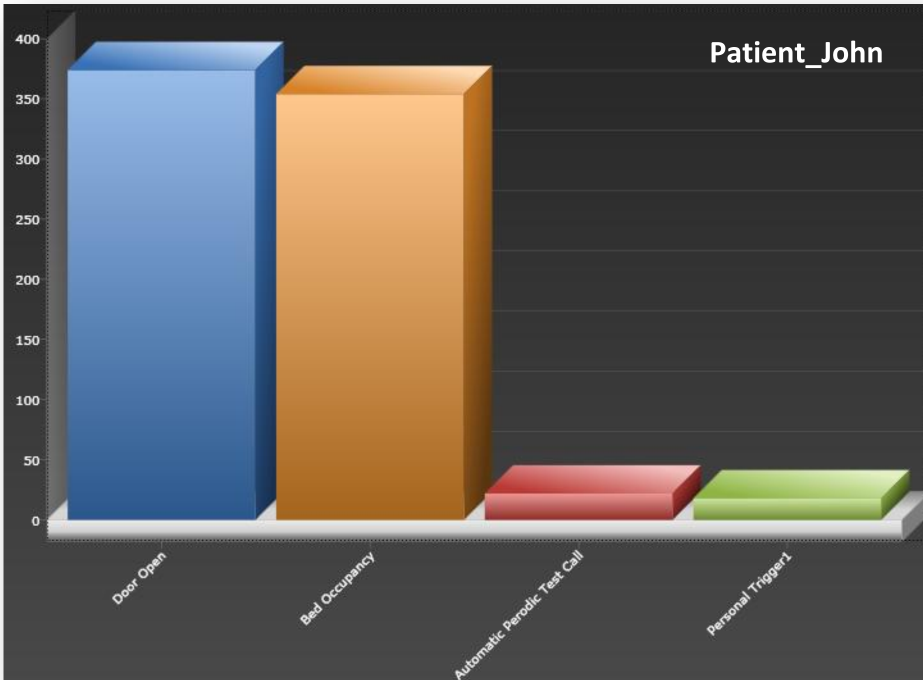
- Motion detectors
- Co2 detector
- Smoke alarm in the hall

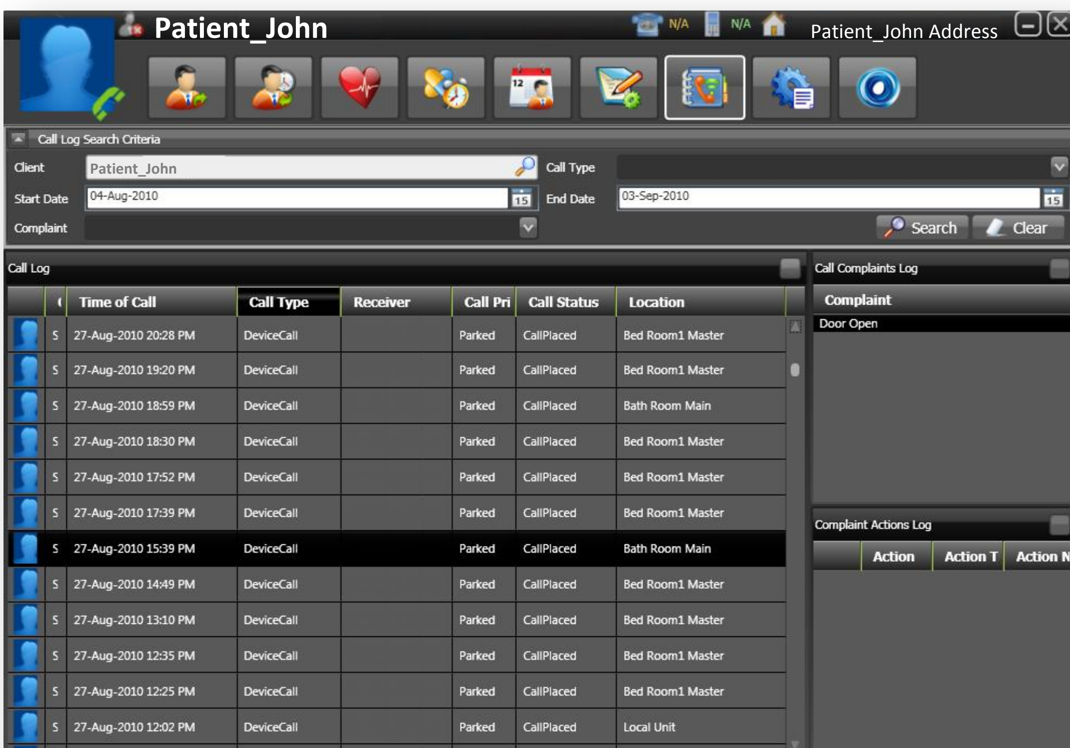
- Fall detector at foot of stairs.

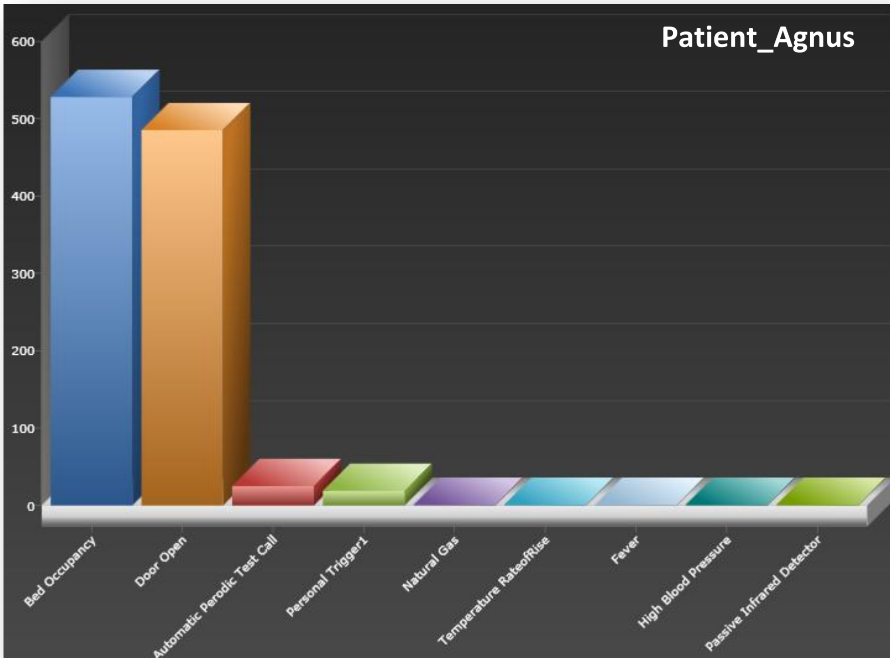
Other

Patient should be provided with a wearable panic button.

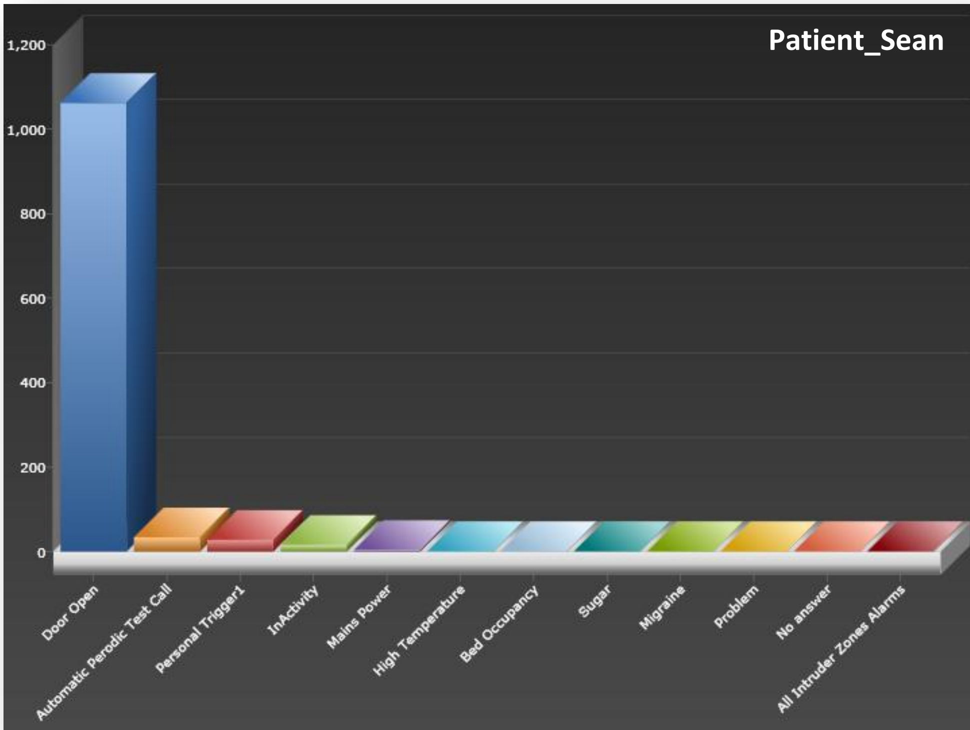
Appendix 7 - Results Vivasta Pilot






Patient_Agnus
600
500
400
300
200
100
0
Bed Occupancy
Door Open
Automatic Perodic Test Call
Personal Trigger1
Natural Gas
Temperature RateofRise
Fever
High Blood Pressure
Passive Infrared Detector


Patient_Agnus
N/A
N/A
Patient_Agnus Address
Call Log Search Criteria
Client
Patient_Agnus
Call Type
Start Date
04-Jun-2010
End Date
03-Sep-2010
Complaint
Search
Clear
Call Log
Time of Call
Call Type
Receiver
Call Priority
Call Status
Location
02-Jul-2010 04:46 A DeviceCall FollowUp CallPlaced Bed Room1 Master
02-Jul-2010 04:40 A DeviceCall FollowUp CallPlaced Bed Room1 Master
01-Jul-2010 20:49 P DeviceCall FollowUp CallPlaced Bed Room1 Master
01-Jul-2010 20:43 P DeviceCall FollowUp CallPlaced Bed Room1 Master
01-Jul-2010 19:34 P DeviceCall FollowUp CallPlaced Bath Room Main
01-Jul-2010 19:04 P DeviceCall FollowUp CallPlaced Bed Room1 Master
01-Jul-2010 17:40 P DeviceCall FollowUp CallPlaced Bed Room1 Master
01-Jul-2010 15:32 P DeviceCall FollowUp CallPlaced Bed Room1 Master
01-Jul-2010 15:30 P DeviceCall FollowUp CallPlaced Kitchen Main
01-Jul-2010 15:19 P DeviceCall FollowUp CallPlaced Kitchen Main
01-Jul-2010 15:19 P DeviceCall FollowUp CallPlaced Local Unit
01-Jul-2010 15:15 P DeviceCall FollowUp CallPlaced No Location Inform
Call Complaints Log
Complaint
Bed Occupancy
Complaint Actions Log
Action
Action T
Action N


Patient_Sean
1,200
1,000
800
600
400
200
0
Door Open
Automatic Perodic Test Call
Personal Trigger1
InActivity
Mains Power
High Temperature
Bed Occupancy
Sugar
Migraine
Problem
No answer
All Intruder Zones Alarms


Patient_Sean
N/A
N/A
Patient_Agnus Address
Call Log Search Criteria
Client
Patient_Sean
Call Type
Start Date
04-Jun-2010
End Date
03-Sep-2010
Complaint
Search
Clear
Call Log
Time of Call
Call Type
Receiver
Call Priority
Call Status
Location
30-Jul-2010 17:17 P DeviceCall High CallPlaced Kitchen Area Other
30-Jul-2010 17:14 P DeviceCall High CallPlaced Front Door Main
30-Jul-2010 13:18 P DeviceCall High CallPlaced Front Door Main
30-Jul-2010 13:11 P DeviceCall High CallPlaced Kitchen Area Other
30-Jul-2010 12:02 P DeviceCall High CallPlaced No Location Information
30-Jul-2010 10:02 A DeviceCall High CallPlaced No Location Information
29-Jul-2010 18:17 P DeviceCall High CallPlaced Front Door Main
29-Jul-2010 18:12 P DeviceCall High CallPlaced Front Door Main
29-Jul-2010 17:22 P DeviceCall High CallPlaced Front Door Main
29-Jul-2010 14:21 P DeviceCall High CallPlaced Kitchen Area Other
29-Jul-2010 14:07 P DeviceCall High CallPlaced Kitchen Area Other
29-Jul-2010 13:20 P DeviceCall High CallPlaced Front Door Main
Call Complaints Log
Complaint
InActivity
Complaint Actions Log
Action
Action T
Action N

Appendix 8 – Remote Patient Monitoring Application code

RootViewController.h

```
//
//  RootViewController.h
//  Cardiapp
//
//  Created by Shane Courtney on 10/07/2010.
//  Copyright HealthIT 2010. All rights reserved.
//

#import <UIKit/UIKit.h>
#import "CardiappViewController.h"
#import "AddCardiappViewController.h"

@interface RootViewController : UITableViewController {
	CardiappViewController		*cardiappView;
	AddCardiappViewController *addCardiappView;
}

@property(nonatomic, retain) CardiappViewController *cardiappView;
@property(nonatomic, retain) AddCardiappViewController *addCardiappView;

@end
```

RootViewController.m

```
//
//  RootViewController.m
//  Cardiapp
//
//  Created by Shane Courtney on 10/07/2010.
//  Copyright HealthIT 2010. All rights reserved.
//

#import "RootViewController.h"
#import "CardiappCell.h"
```

```
#import "RPMappAppDelegate.h"
#import "Cardiapp.h"

@implementation RootViewController

@synthesize cardiappView, addCardiappView;

- (void)viewDidLoad {
   [super viewDidLoad];

        self.title=@"Previous readings";
        self.navigationItem.leftBarButtonItem = self.editButtonItem;
        UIBarButtonItem *btn = [[UIBarButtonItem alloc] initWithTitle :@"Add"

         style:UIBarButtonItemStyleBordered

        target:self action:@selector(addCardiapp:)];
        self.navigationItem.rightBarButtonItem = btn;

}

-(void)addCardiapp:(id)sender
{
        RPMappAppDelegate *appDelegate = (RPMappAppDelegate *) [[UIApplication sharedApplication] delegate];

        if (self.addCardiappView == nil){
           AddCardiappViewController * viewController = [[AddCardiappViewController alloc]

initWithNibName:@"AddCardiappViewController"

bundle:[NSBundle mainBundle]];
           self.addCardiappView = viewController;
           [viewController release];
        }

        Cardiapp *cardiapp = [appDelegate addCardiapp];
        [self.navigationController pushViewController:self.addCardiappView animated:YES];
        self.addCardiappView.cardiapp = cardiapp;
        self.addCardiappView.title = @"New Readings";
}

- (void)viewWillAppear:(BOOL)animated {
```

```
        [self.tableView reloadData];
    [super viewWillAppear:animated];
}

- (void)didReceiveMemoryWarning {
        // Releases the view if it doesn't have a superview.
    [super didReceiveMemoryWarning];

        // Release any cached data, images, etc that aren't in use.
}

- (void)viewDidUnload {
        // Release anything that can be recreated in viewDidLoad or on demand.
        // e.g. self.myOutlet = nil;
}

#pragma mark Table view methods

- (NSInteger)numberOfSectionsInTableView:(UITableView *)tableView {
    return 1;
}

// Customize the number of rows in the table view.
- (NSInteger)tableView:(UITableView *)tableView numberOfRowsInSection:(NSInteger)section {
        RPMappAppDelegate *appDelegate = (RPMappAppDelegate *)[[UIApplication sharedApplication] delegate];
    return appDelegate.cardiapps.count;
}

// Customize the appearance of table view cells.
- (UITableViewCell *)tableView:(UITableView *)tableView cellForRowAtIndexPath:(NSIndexPath *)indexPath {

    static NSString *MyIdentifier = @"MyIdentifier";

    CardiappCell *cell = (CardiappCell *)[tableView dequeueReusableCellWithIdentifier:MyIdentifier];

    if (cell == nil) {
        cell = [[[CardiappCell alloc] initWithFrame:CGRectZero reuseIdentifier:MyIdentifier] autorelease];
    }

        RPMappAppDelegate *appDelegate = (RPMappAppDelegate *)[[UIApplication sharedApplication] delegate];
        Cardiapp *ca = [appDelegate.cardiapps objectAtIndex:indexPath.row];
```

```
            [cell setCardiapp:ca];


    return cell;
}

// Override to support row selection in the table view.
- (void)tableView:(UITableView *)tableView didSelectRowAtIndexPath:(NSIndexPath *)indexPath {

            RPMappAppDelegate *appDelegate = (RPMappAppDelegate *) [[UIApplication sharedApplication] delegate];
            Cardiapp *cardiapp = (Cardiapp *)[appDelegate.cardiapps objectAtIndex:indexPath.row];

            if(self.cardiappView == nil){
              CardiappViewController *viewController = [[CardiappViewController alloc]

initWithNibName:@"CardiappViewController" bundle:[NSBundle mainBundle]];
              self.cardiappView = viewController;
              [viewController release];
            }

            [self.navigationController pushViewController:self.cardiappView animated:YES];
            self.cardiappView.cardiapp = cardiapp;
            self.cardiappView.title = cardiapp.reading_time;
            self.cardiappView.cardiappBpLabel.text = [NSString stringWithFormat:@"%d-%d",cardiapp.systolic,
cardiapp.diastolic];
            self.cardiappView.cardiappPrLabel.text = [NSString stringWithFormat:@"%d",cardiapp.pulse];
            self.cardiappView.cardiappWeightLabel.text = [NSString stringWithFormat:@"%d kg",cardiapp.pweight];
            self.cardiappView.cardiappSao2Label.text = [NSString stringWithFormat:@"%d",cardiapp.sao2];
            [self.cardiappView.cardiappText setText:cardiapp.notes];
}

- (void)tableView:(UITableView *)tableView commitEditingStyle:(UITableViewCellEditingStyle)editingStyle
forRowAtIndexPath:(NSIndexPath *)indexPath {

            RPMappAppDelegate *appDelegate = (RPMappAppDelegate *)[[UIApplication sharedApplication] delegate];
            Cardiapp *cardiapp = (Cardiapp *)[appDelegate.cardiapps objectAtIndex:indexPath.row];

    if (editingStyle == UITableViewCellEditingStyleDelete) {

        // Delete the row from the data source.
        [appDelegate removeCardiapp:cardiapp];
              [tableView deleteRowsAtIndexPaths:[NSArray arrayWithObject:indexPath]
```

```
withRowAnimation:UITableViewRowAnimationFade];
   }
   else if (editingStyle == UITableViewCellEditingStyleInsert) {
      // Create a new instance of the appropriate class, insert it into the array, and add a new row to the table view.
   }
}

- (void)dealloc {
   [super dealloc];
}


@end
```

RPMappAppDelegate.h

```
//
// RPMappAppDelegate.h
// Created by Shane Courtney on 10/07/2010.
// Copyright HealthIT 2010. All rights reserved.
//

#import <UIKit/UIKit.h>
#import <sqlite3.h>
#import "Cardiapp.h"

@interface RPMappAppDelegate : NSObject <UIApplicationDelegate> {

  UIWindow *window;
  UINavigationController *navigationController;

        sqlite3 *database;

        // This array will populate the UITableView
        NSMutableArray *cardiapps;
}

@property (nonatomic, retain) IBOutlet UIWindow *window;
@property (nonatomic, retain) IBOutlet UINavigationController *navigationController;
@property (nonatomic, retain) NSMutableArray *cardiapps;

-(Cardiapp *)addCardiapp;
-(void)removeCardiapp:(Cardiapp *)cardiapp;

@end
```

RPMappAppDelegate.m

```
//
// RPMappAppDelegate.m
// Created by Shane Courtney on 10/07/2010.
// Copyright HealthIT 2010. All rights reserved.
//
```

```
#import "RPMappAppDelegate.h"
#import "RootViewController.h"
#import "Cardiapp.h"

#define DEBUG

// Specific to this object so does not need to be declared in .h file
@interface RPMappAppDelegate (Private)
-(void)createEditableCopyOfDatabaseIfNeeded;
-(void)initializeDatabase;
@end


@implementation RPMappAppDelegate
@synthesize window, navigationController, cardiapps;

//
// Copies the database from the projects folder to the documents folder on your Iphone.
// This will only happen the once as it checks if the db already exoists in this folder

-(void)createEditableCopyOfDatabaseIfNeeded
{
	//  First test we test for existence.
	BOOL success;
	NSFileManager *fileManager = [NSFileManager defaultManager];
	NSError *error;
	NSArray *paths = NSSearchPathForDirectoriesInDomains(NSDocumentDirectory, NSUserDomainMask, YES);
	NSString *documentsDirectory = [paths objectAtIndex:0];
	NSString *writableBDPath = [documentsDirectory stringByAppendingPathComponent:@"cardiapp.sqlite"];
	success = [fileManager fileExistsAtPath:writableBDPath];

	if (success) return;
	// The writeable db does not exist, so copy the default to the appropriate location
	NSString *defaultDBPath = [[[NSBundle mainBundle] resourcePath]
stringByAppendingPathComponent:@"cardiapp.sqlite"];
	success = [fileManager copyItemAtPath:defaultDBPath toPath:writableBDPath error:&error];

	if (!success)
	{
	   NSAssert1(0, @"Failed to create writeable database file with message '%@'.", [error localizedDescription]);
	   NSLog(@"Database could not be created");
```

```
        }
}

-(void)initializeDatabase
{
        NSMutableArray *cardiappArray = [[NSMutableArray alloc] init];
        self.cardiapps = cardiappArray;
        [cardiappArray release];

        // The db is stored in the applications bundle
        NSArray *paths = NSSearchPathForDirectoriesInDomains(NSDocumentDirectory, NSUserDomainMask, YES);
        NSString *documentsDirectory = [paths objectAtIndex:0];
        NSString *path = [documentsDirectory stringByAppendingPathComponent:@"cardiapp.sqlite"];

        //  Open the database that was prepared outside the application
        if(sqlite3_open([path UTF8String], &database) == SQLITE_OK)
        {
          // Get primary Key of all cardiapp rows
          const char *sql = "SELECT pk FROM cardiapp";
          sqlite3_stmt *statement;

          // Preparing a statement compiles the SQL query into a byte-code program in the SQLite library
          // The third parameter is either the length of the sql string or -1 to read up to the first null terminator
          if (sqlite3_prepare_v2(database, sql, -1, &statement, NULL) == SQLITE_OK)
          {
                  // Step through the results - one for each row.
                  while (sqlite3_step(statement) == SQLITE_ROW)
                  {
                          // The second parameter indicates the column index into the results set
                          int primaryKey = sqlite3_column_int(statement, 0);

                          Cardiapp *ca = [[Cardiapp alloc] initWithPrimaryKey:primaryKey database:database];
                          [cardiapps addObject:ca];
                          [ca release];
                  }

          }

          // Finialize the statement - releases the resourses assoicated with the statement
          sqlite3_finalize(statement);
```

```
        // Sorting the mutable array by the reading_time field
        NSSortDescriptor * sortDesc = [[NSSortDescriptor alloc] initWithKey:(@"reading_time") ascending:NO];
        [self.cardiapps sortUsingDescriptors:[NSArray arrayWithObject:sortDesc]];
    }
    else
    {
        // Even though the open failed, call close to properly clean up resources
        sqlite3_close(database);
        NSAssert1(0, @"Failed to open database with message '%s'.", sqlite3_errmsg(database));
        NSLog(@"Failed to open database");

    }
}

-(Cardiapp *) addCardiapp{
    NSInteger primaryKey = [Cardiapp insertNewCardiappIntoDatabase:database];
    Cardiapp *newCardiapp = [[Cardiapp alloc] initWithPrimaryKey:primaryKey database:database];
    [cardiapps addObject:newCardiapp];
    return newCardiapp;
}

-(void)removeCardiapp:(Cardiapp *)cardiapp{
    NSInteger index = [cardiapps indexOfObject:cardiapp];
    if(index == NSNotFound) return;

    [cardiapp deleteFromDatabase];
    [cardiapps removeObject:cardiapp];
}

#pragma mark -
#pragma mark Application lifecycle

- (void)applicationDidFinishLaunching:(UIApplication *)application {

  // Override point for customization after app launch
    [self createEditableCopyOfDatabaseIfNeeded];
    [self initializeDatabase];

    [window addSubview:[navigationController view]];
  [window makeKeyAndVisible];
}
```

```
- (void)applicationWillTerminate:(UIApplication *)application {

        // Here we will save the data to the database when the application terminates.
        [cardiapps makeObjectsPerformSelector:@selector(dehydrate)];
}

#pragma mark -
#pragma mark Memory management

- (void)dealloc {
        [navigationController release];
        [window release];
        [super dealloc];
}

@end
```

Cardiapp.h

```
//
//  Cardiapp.h
//  Cardiapp
//
//  Created by Shane Courtney on 10/07/2010.
//  Copyright 2010 HealthIT. All rights reserved.
//
//  Object to hold the cardiapp.sql information
//

#import <UIKit/UIKit.h>
#import <sqlite3.h>
#import <MessageUI/MessageUI.h>
#import <MessageUI/MFMessageComposeViewController.h>

@interface Cardiapp : NSObject
//<MFMessageComposeViewControllerDelegate>
{
        sqlite3 *database;  // reference to apps db, it will allow this object to communicate with it
        NSInteger primaryKey;
        NSInteger systolic;
        NSInteger diastolic;
```

```
        NSInteger pulse;
        NSInteger sao2;
        NSInteger pweight;
        NSString *reading_time;
        NSString *notes;
        NSInteger status;
        BOOL dirty;  // I will use this to signify when a Notes ha been altered
}

@property (assign, nonatomic, readonly) NSInteger primaryKey;    // Unique ID, once assigned it cannot be changed!
@property (nonatomic) NSInteger systolic;
@property (nonatomic) NSInteger diastolic;
@property (nonatomic) NSInteger pulse;
@property (nonatomic) NSInteger sao2;
@property (nonatomic) NSInteger pweight;
@property (nonatomic, retain) NSString *reading_time;
@property (nonatomic, retain) NSString *notes;
@property (nonatomic) NSInteger status;

/* This method is the constructor for this object, it takes an integer to assign as the primary
 key and an sqlite3 object to use as the db */

-(id)initWithPrimaryKey:(NSInteger)pk database:(sqlite3 *)db;

-(void)updateNotes:(NSString *)newNotes;
-(void)updateSystolic:(NSString *)newSystolic;
-(void)updateDiastolic:(NSString *)newDiastolic;
-(void)updatePulse:(NSString *)newPulse;
-(void)updateSao2:(NSString *)newSao2;
-(void)updateWeight:(NSString *)newWeight;
-(void)updateReading:(NSString *)readingTime;

-(void)dehydrate;
-(void)deleteFromDatabase;
+(NSInteger)insertNewCardiappIntoDatabase:(sqlite3 *)database;

@end
```

Cardiapp.m

```
//
```

```
//  Cardiapp.m
//  Cardiapp
//
//  Created by Shane Courtney on 10/07/2010.
//  Copyright 2010 HealthIT. All rights reserved.
//

#import "Cardiapp.h"


//  This statement will hold our initialise statement when retrieving data from db
static sqlite3_stmt *init_statement = nil;
static sqlite3_stmt *dehydrate_statment = nil;
static sqlite3_stmt *delete_statement = nil;
static sqlite3_stmt *insert_statement = nil;

@implementation Cardiapp
@synthesize primaryKey, systolic, diastolic, pulse, sao2, pweight, reading_time, notes, status;

-(void)updateNotes:(NSString *)newNotes
{
	if(newNotes == NULL){
	   self.notes = @"No notes attached!";
	}
	else
	{
	   self.notes = newNotes;
	}
	dirty = YES;
}

-(void)updateSystolic:(NSString *)newSystolic {
	self.systolic = [newSystolic intValue];
	dirty = YES;
}

-(void)updateDiastolic:(NSString *)newDiastolic{
	self.diastolic = [newDiastolic intValue];
	dirty = YES;
}

-(void)updatePulse:(NSString *)newPulse{
```

```
        self.pulse = [newPulse intValue];
        dirty = YES;
}

-(void)updateSao2:(NSString *)newSao2{
        self.sao2 = [newSao2 intValue];
        dirty = YES;

}

-(void)updateWeight:(NSString *)newWeight{
        self.pweight = [newWeight intValue];
        dirty = YES;
}

-(void)updateReading:(NSString *)readingTime{
        self.reading_time = readingTime;
        dirty = YES;
}

-(void)dehydrate {
        if(dirty) {
          if (dehydrate_statment == nil){
                    const char *sql = "UPDATE cardiapp SET systolic = ?, diastolic = ?, pulse = ?, sao2 = ?, weight = ?, notes =
?, time = ? WHERE pk=?";
                    if(sqlite3_prepare_v2(database, sql, -1, &dehydrate_statment, NULL) != SQLITE_OK){
                              NSAssert1(0, @"Error: failed to prepare statement with messahe
'%s'.",sqlite3_errmsg(database));
                    }
          }

          sqlite3_bind_int(dehydrate_statment, 8, self.primaryKey);
          sqlite3_bind_text(dehydrate_statment,7, [self.reading_time UTF8String], -1, SQLITE_TRANSIENT);
          sqlite3_bind_text(dehydrate_statment,6, [self.notes UTF8String], -1, SQLITE_TRANSIENT);
          sqlite3_bind_int(dehydrate_statment, 5, self.pweight);
          sqlite3_bind_int(dehydrate_statment, 4, self.sao2);
          sqlite3_bind_int(dehydrate_statment, 3, self.pulse);
          sqlite3_bind_int(dehydrate_statment, 2, self.diastolic);
          sqlite3_bind_int(dehydrate_statment, 1, self.systolic);


          int success = sqlite3_step(dehydrate_statment);
```

```
            if (success != SQLITE_DONE){
                NSAssert1(0, @"Error: failed to save notes with nessage '%s'.", sqlite3_errmsg(database));
            }

            sqlite3_reset(dehydrate_statment);
            dirty = NO;


        }
}

+(NSInteger)insertNewCardiappIntoDatabase:(sqlite3 *)database
{

        if(insert_statement == nil){
            static char *sql = "INSERT INTO cardiapp(time, systolic, diastolic, pulse, sao2, weight, notes, complete) VALUES
(0, 0, 0,0,0, 0, 0, 0)";
            if(sqlite3_prepare_v2(database, sql, -1, &insert_statement, NULL) != SQLITE_OK){
                NSAssert1(0,@"Error: failed to prepare statement with message '%s'.", sqlite3_errmsg(database));
            }
        }

        int success = sqlite3_step(insert_statement);
        sqlite3_reset(insert_statement);

        if(success != SQLITE_ERROR){
            return sqlite3_last_insert_rowid(database);
        }
        NSAssert1(0, @"Error: failed to insert into the database with message '%s'.", sqlite3_errmsg(database));
        return -1;

}


-(id)initWithPrimaryKey:(NSInteger)pk database:(sqlite3 *)db
{

        if (self = [super init]){

            primaryKey = pk;
            database = db;
```

```
            // Create new string containing sql statement if init_statement is null
            if (init_statement == nil)
            {
                        const char *sql = "SELECT notes, systolic, diastolic, pulse, sao2, weight, time FROM cardiapp WHERE pk
=?";
                        //  Prepare statement and store it in init_statment
                        if (sqlite3_prepare_v2(database, sql, -1, &init_statement, NULL)!= SQLITE_OK)
                        {
                                    NSAssert1(0,@"Error: failed to prepare database with message '%s'.",
sqlite3_errmsg(database));
                        }
            }

            sqlite3_bind_int(init_statement, 1, primaryKey);

            // executes the init_statement on the database.  Placed in an IF statement to make sure it executes properly!
            if (sqlite3_step(init_statement) == SQLITE_ROW)
            {
                        self.notes = [NSString stringWithUTF8String:(char *)sqlite3_column_text(init_statement, 0)];
                        self.systolic = sqlite3_column_int(init_statement, 1);
                        self.diastolic = sqlite3_column_int(init_statement, 2);
                        self.pulse = sqlite3_column_int(init_statement, 3);
                        self.sao2 = sqlite3_column_int(init_statement, 4);
                        self.pweight = sqlite3_column_int(init_statement, 5);
                        self.reading_time = [NSString stringWithUTF8String:(char *)sqlite3_column_text(init_statement, 6)];
            }
            else
            {
                        self.notes = @"Nothing";
            }
            //  reset the statement for future use
            sqlite3_reset(init_statement);
        }
        return self;
}

-(void) deleteFromDatabase{
        if(delete_statement == nil){

            const char *sql = "DELETE FROM cardiapp WHERE pk=?";
            if(sqlite3_prepare_v2(database, sql, -1, &delete_statement, NULL) != SQLITE_OK){
                        NSAssert1(0,@"Error: failed to prepare statement with message '%s'.", sqlite3_errmsg(database));
```

```
        }
    }
    sqlite3_bind_int(delete_statement, 1, self.primaryKey);

    int success = sqlite3_step(delete_statement);
    if(success != SQLITE_DONE){
        NSAssert1(0,@"Error: failed to save priority with message '%s'.", sqlite3_errmsg(database));
    }
    sqlite3_reset(delete_statement);
}

@end
```

CardiappCell.h

```
//
//  CardiappCell.h
//  Cardiapp
//
//  Created by Shane Courtney on 10/07/2010.
//  Copyright 2010 HealthIT. All rights reserved.
//

#import <UIKit/UIKit.h>
#import "Cardiapp.h";


@interface CardiappCell : UITableViewCell {

    Cardiapp *cardiapp;
    UILabel *cardiaSystolicLabel;
    UILabel *cardiaDiastolicLabel;
    UILabel *cardiaPulseLabel;
    UILabel *cardiaSao2Label;
    UILabel *cardiaPweightLabel;
    UILabel *cardiaReading_timeLabel;
    UILabel *cardiaNotesLabel;
    UIImageView *cardiaWarningLevelLabel;
    UILabel *cardiaWarningLabelText;
```

```
}

@property (nonatomic, retain) UILabel *cardiaSystolicLabel;
@property (nonatomic, retain) UILabel *cardiaDiastolicLabel;
@property (nonatomic, retain) UILabel *cardiaPulseLabel;
@property (nonatomic, retain) UILabel *cardiaSao2Label;
@property (nonatomic, retain) UILabel *cardiaPweightLabel;
@property (nonatomic, retain) UILabel *cardiaReading_timeLabel;
@property (nonatomic, retain) UILabel *cardiaNotesLabel;
@property (nonatomic, retain) UIImageView *cardiaWarningLevelLabel;
@property (nonatomic, retain) UILabel *cardiaWarningLabelText;


-(UIImage *)imageForWarningLevelLabel:(NSInteger)systolic;


-(Cardiapp*)cardiapp;
-(void)setCardiapp:(Cardiapp *)newCardiapp;


@end
```

CardiappCell.m

```
//
//  CardiappCell.m
//  Cardiapp
//
//  Created by Shane Courtney on 10/07/2010.
//  Copyright 2010 HealthIT. All rights reserved.
//

#import "CardiappCell.h"

#define settingsPatientID               @"pateintid"
#define settingsPatientWeight           @"weight"
#define settingsPatientSystolic         @"systolic"
#define settingsPatientDiastolic    @"diastolic"
#define settingsGpNumber                @"gp"
#define settingsNurseNumber                     @"nurse"
```

```
#define settingsNOKNumber                      @"nok"
#define settingsGpEmail                        @"gpemail"
#define settingsNurseEmail               @"nurseemail"



static UIImage *warningLevel1Image = nil;
static UIImage *warningLevel2Image = nil;
static UIImage *warningLevel3Image = nil;
static UIImage *warningLevel4Image = nil;


@interface CardiappCell()

-(UILabel *)newLabelWithPrimaryColor:(UIColor *)primaryColor selectedColor:(UIColor *)selectedColor
                                        fontSize:(CGFloat)fontSize bold:(BOOL)bold;

@end



@implementation CardiappCell

@synthesize cardiaSystolicLabel, cardiaDiastolicLabel, cardiaPulseLabel,cardiaSao2Label, cardiaPweightLabel,
cardiaReading_timeLabel, cardiaNotesLabel, cardiaWarningLevelLabel, cardiaWarningLabelText;

+(void)initialize
{
    //  The warningLevel Images are part of the class so they need to be explicitly retained.
    warningLevel1Image = [[UIImage imageNamed:@"Heart.png"]retain];
    warningLevel2Image = [[UIImage imageNamed:@"Warning.png"]retain];
    warningLevel3Image = [[UIImage imageNamed:@"Alarm.png"]retain];
    warningLevel4Image = [[UIImage imageNamed:@"ThumbsUp.png"]retain];

}
// UIFont boldSystemFontOfSize:fontSize

- (id)initWithStyle:(UITableViewCellStyle)style reuseIdentifier:(NSString *)reuseIdentifier {
    if (self = [super initWithStyle:style reuseIdentifier:reuseIdentifier])
    {

      UIView *myContentView = self.contentView;
```

```
// add cardiaWarningLevelLabel to myContentView
self.cardiaWarningLevelLabel = [[UIImageView alloc] initWithImage:warningLevel4Image];
[myContentView addSubview:self.cardiaWarningLevelLabel];
[self.cardiaWarningLevelLabel release];


// add cardiaSystolicLabel to myContentView

self.cardiaSystolicLabel = [self newLabelWithPrimaryColor:[UIColor blackColor]

    selectedColor:[UIColor whiteColor]

fontSize:12 bold:YES];
self.cardiaSystolicLabel.textAlignment = UITextAlignmentLeft;
[myContentView addSubview:cardiaSystolicLabel];
[cardiaSystolicLabel release];


// add cardiaDiastolicLabel to myContentView
self.cardiaDiastolicLabel = [self newLabelWithPrimaryColor:[UIColor blackColor]

selectedColor:[UIColor whiteColor]

fontSize:12 bold:YES];
self.cardiaDiastolicLabel.textAlignment = UITextAlignmentLeft;
[myContentView addSubview:cardiaDiastolicLabel];
[cardiaDiastolicLabel release];

// add cardiaPulseLabel to myContentView
self.cardiaPulseLabel = [self newLabelWithPrimaryColor:[UIColor blackColor]

selectedColor:[UIColor whiteColor]

fontSize:12 bold:YES];
self.cardiaPulseLabel.textAlignment = UITextAlignmentLeft;
[myContentView addSubview:cardiaPulseLabel];
[cardiaPulseLabel release];


// add cardiaSao2Label to myContentView
```

```
    self.cardiaSao2Label = [self newLabelWithPrimaryColor:[UIColor blackColor]

  selectedColor:[UIColor whiteColor]

fontSize:12 bold:YES];
    self.cardiaSao2Label.textAlignment = UITextAlignmentLeft;
    [myContentView addSubview:cardiaSao2Label];
    [cardiaSao2Label release];


    // add cardiaPweightLabel to myContentView
    self.cardiaPweightLabel = [self newLabelWithPrimaryColor:[UIColor blackColor]

selectedColor:[UIColor whiteColor]

  fontSize:12 bold:YES];
    self.cardiaPweightLabel.textAlignment = UITextAlignmentLeft;
    [myContentView addSubview:cardiaPweightLabel];
    [cardiaPweightLabel release];

    // add cardiaReading_timeLabel to myContentView
    self.cardiaReading_timeLabel = [self newLabelWithPrimaryColor:[UIColor blueColor]
                                   selectedColor:[UIColor whiteColor]
                                    fontSize:12
                                   bold:YES];
    self.cardiaReading_timeLabel.textAlignment = UITextAlignmentLeft;
    [myContentView addSubview:cardiaReading_timeLabel];
    [cardiaReading_timeLabel release];

    // add cardiaNotesLabel to myContentView
    self.cardiaNotesLabel = [self newLabelWithPrimaryColor:[UIColor blackColor]

selectedColor:[UIColor whiteColor]

fontSize:12 bold:YES];
    self.cardiaNotesLabel.textAlignment = UITextAlignmentLeft;
    [myContentView addSubview:cardiaNotesLabel];
    [cardiaNotesLabel release];

    // add cardiaWarningTextLabel to myContentView
    self.cardiaWarningLabelText = [self newLabelWithPrimaryColor:[UIColor redColor]
```

```
selectedColor:[UIColor whiteColor]

        fontSize:12 bold:YES];
          self.cardiaWarningLabelText.textAlignment = UITextAlignmentLeft;
          [myContentView addSubview:cardiaWarningLabelText];
          [cardiaWarningLabelText release];

          [myContentView bringSubviewToFront:self.cardiaWarningLevelLabel];
        }

        return self;
}
// Getter and setter method for the Cardiapp object.
-(Cardiapp*)cardiapp
{
        return self.cardiapp;
}

-(void)setCardiapp:(Cardiapp *)newCardiapp
{
        cardiapp = newCardiapp;
        self.cardiaWarningLevelLabel.image = [self imageForWarningLevelLabel:newCardiapp.systolic ];
        NSUserDefaults *defaults = [NSUserDefaults standardUserDefaults];
        NSString *settingPatientWeight = [defaults objectForKey:settingsPatientWeight];
        NSInteger patientWeightIncreaseLevel = [settingPatientWeight intValue] +2;

        // HIGH BP warning message
        if (newCardiapp.systolic > 120 && newCardiapp.systolic < 140){
          self.cardiaWarningLabelText.text = [NSString stringWithFormat:@"Prehypertension!!
%d",newCardiapp.systolic];
        }

        // Very HIGH BP warning message
        else if (newCardiapp.systolic >= 140 && newCardiapp.systolic < 160){
          self.cardiaWarningLabelText.text = [NSString stringWithFormat:@"%d High BP - Stage
1",newCardiapp.systolic];
        }

        // Critical BP warning message
        else if (newCardiapp.systolic >= 160 && newCardiapp.systolic < 180){
          self.cardiaWarningLabelText.text = [NSString stringWithFormat:@"%d High BP - Stage
2",newCardiapp.systolic];
```

```
        }

        else if (newCardiapp.systolic >= 180){
          self.cardiaWarningLabelText.text = [NSString stringWithFormat:@"%d Critical BP Call
999",newCardiapp.systolic];
        }

        // Low SAO2 warning message
        else if ( newCardiapp.systolic <= 120 && newCardiapp.sao2 < 95)
        {
          self.cardiaWarningLabelText.text = [NSString stringWithFormat:@"Low SAO2 LEVEL!! %d",newCardiapp.sao2];
        }

        // Weight gain warning message

        else if ( newCardiapp.systolic <= 120 && newCardiapp.pweight > patientWeightIncreaseLevel)
        {
          self.cardiaWarningLabelText.text = [NSString stringWithFormat:@"Weight Increase!
%d",newCardiapp.pweight];
        }

        // Default warning message
        else
        {
          self.cardiaWarningLabelText.text = [NSString stringWithFormat:@""];
        }

        self.cardiaSystolicLabel.text = [NSString stringWithFormat:@"BP: %d /",newCardiapp.systolic];
        self.cardiaDiastolicLabel.text =  [NSString stringWithFormat:@"%d",newCardiapp.diastolic];
        self.cardiaPulseLabel.text = [NSString stringWithFormat:@"PR: %d", newCardiapp.pulse];
        self.cardiaSao2Label.text = [NSString stringWithFormat:@"Sao2: %d",newCardiapp.sao2];
        self.cardiaPweightLabel.text = [NSString stringWithFormat:@"Weight: %d",newCardiapp.pweight];
        self.cardiaReading_timeLabel.text = newCardiapp.reading_time;
        self.cardiaNotesLabel.text = newCardiapp.notes;

        [self setNeedsDisplay];
}

-(void)layoutSubviews
{
#define LEFT_COLUMN_OFFSET 1
#define TOP_ROW_WIDTH 5
```

```
#define BOTTOM_ROW_WIDTH 20

    [super layoutSubviews];
    CGRect contentRect = self.contentView.bounds;


    if (!self.editing)
    {
      CGFloat boundsX = contentRect.origin.x;
      CGRect frame;

      // Place the warning image
      UIImageView *imageView = self.cardiaWarningLevelLabel;
      frame = [imageView frame];
      frame.origin.x = boundsX + LEFT_COLUMN_OFFSET;
      frame.origin.y = 05;
      imageView.frame = frame;

      // Place the cardiaSystolicLabel label

      frame = CGRectMake(35, TOP_ROW_WIDTH, 70, 13);
      self.cardiaSystolicLabel.frame = frame;

      // Place the cardiaDiastolicLabel label

      frame = CGRectMake(90, TOP_ROW_WIDTH, 20, 13);
      self.cardiaDiastolicLabel.frame = frame;

      // Place the cardiaPulseLabel label
      frame = CGRectMake(120, TOP_ROW_WIDTH, 50, 13);
      self.cardiaPulseLabel.frame = frame;

      // Place the cardiaSao2Label label
      frame = CGRectMake(170, TOP_ROW_WIDTH, 60, 13);
      self.cardiaSao2Label.frame = frame;

      // Place the cardiaPweightLabel label
      frame = CGRectMake(240, TOP_ROW_WIDTH, 150, 13);
      self.cardiaPweightLabel.frame = frame;

      // Place the cardiaReading_timeLabel label
      frame = CGRectMake(35, BOTTOM_ROW_WIDTH, 140, 20);
```

```
        self.cardiaReading_timeLabel.frame = frame;

        //  Warning level label
        frame = CGRectMake(160, BOTTOM_ROW_WIDTH , 280, 20);
        self.cardiaWarningLabelText.frame = frame;

    }
}

-(void)setSelected:(BOOL)selected animated:(BOOL)animated
{
    [super setSelected:selected animated:animated];

    UIColor *backgroundColor = nil;
    if(selected)
    {
        backgroundColor = [UIColor clearColor];
    }
    else {
        backgroundColor = [UIColor whiteColor];
    }

    self.cardiaWarningLevelLabel.backgroundColor = backgroundColor;
    self.cardiaWarningLevelLabel.highlighted = selected;
    self.cardiaWarningLevelLabel.opaque = !selected;

    self.cardiaSystolicLabel.backgroundColor = backgroundColor;
    self.cardiaSystolicLabel.highlighted = selected;
    self.cardiaSystolicLabel.opaque = !selected;

    self.cardiaDiastolicLabel.backgroundColor = backgroundColor;
    self.cardiaDiastolicLabel.highlighted = selected;
    self.cardiaDiastolicLabel.opaque = !selected;

    self.cardiaPulseLabel.backgroundColor = backgroundColor;
    self.cardiaPulseLabel.highlighted = selected;
    self.cardiaPulseLabel.opaque = !selected;

    self.cardiaSao2Label.backgroundColor = backgroundColor;
    self.cardiaSao2Label.highlighted = selected;
    self.cardiaSao2Label.opaque = !selected;
```

```
        self.cardiaPweightLabel.backgroundColor = backgroundColor;
        self.cardiaPweightLabel.highlighted = selected;
        self.cardiaPweightLabel.opaque = !selected;

        self.cardiaReading_timeLabel.backgroundColor = backgroundColor;
        self.cardiaReading_timeLabel.highlighted = selected;
        self.cardiaReading_timeLabel.opaque = !selected;

        self.cardiaNotesLabel.backgroundColor = backgroundColor;
        self.cardiaNotesLabel.highlighted = selected;
        self.cardiaNotesLabel.opaque = !selected;
}
//  This next methid is called when we initialize our labels.  It takes a few parameters that are self explanatory
-(UILabel *)newLabelWithPrimaryColor:(UIColor *)primaryColor
                                selectedColor:(UIColor *)selectedColor fontSize:(CGFloat)fontSize
bold:(BOOL)bold {
        UIFont *font;
        if (bold) {
          font = [UIFont boldSystemFontOfSize:fontSize];
        } else{
          font = [UIFont systemFontOfSize:fontSize];
        }

        UILabel *newLabel = [[UILabel alloc] initWithFrame:CGRectZero];
        newLabel.backgroundColor = [UIColor whiteColor];
        newLabel.opaque = YES;
        newLabel.textColor = primaryColor;
        newLabel.highlightedTextColor = selectedColor;
        newLabel.font = font;

        return newLabel;
}

// This method simply returns a priority and returns the UIImage that is associated with this priority
// Notice the default clause, i done this like that beacsue if there was ever another priority != 1,2,3
// it can be accounted for and will have low priority

-(UIImage *)imageForWarningLevelLabel:(NSInteger)systolic
{
        if(systolic > 120 && systolic < 139)
        {
          return warningLevel1Image;
```

```
    }
    else if (systolic > 140 && systolic < 159)
    {
        return warningLevel2Image;
    }
    else if (systolic > 160)
    {
        return warningLevel3Image;
    }
    else
    {
        return warningLevel4Image;
    }
    return nil;
}

- (void)dealloc {
    [super dealloc];
}


@end
```

CardiappViewController.h

```
//
//  CardiappViewController.h
//  Cardiapp
//
//  Created by Shane Courtney on 16/07/2010.
//  Copyright 2010 HealthIT. All rights reserved.
//

#import <UIKit/UIKit.h>
#import "Cardiapp.h"


@interface CardiappViewController : UIViewController {

    IBOutlet UITextView         *cardiappText;
    IBOutlet UILabel            *cardiappBpLabel;
```

```
	IBOutlet UILabel		*cardiappPrLabel;
	IBOutlet UILabel		*cardiappSao2Label;
	IBOutlet UILabel		*cardiappWeightLabel;
	IBOutlet UILabel		*cardiappStatus;
	IBOutlet UIButton		*cardiappButton;
	Cardiapp			*cardiapp;

}

@property(nonatomic, retain) IBOutlet UITextView		*cardiappText;
@property(nonatomic, retain) IBOutlet UILabel			*cardiappBpLabel;
@property(nonatomic, retain) IBOutlet UILabel			*cardiappPrLabel;
@property(nonatomic, retain) IBOutlet UILabel			*cardiappSao2Label;
@property(nonatomic, retain) IBOutlet UILabel			*cardiappWeightLabel;
@property(nonatomic, retain) IBOutlet UILabel			*cardiappStatus;
@property(nonatomic, retain) IBOutlet UIButton			*cardiappButton;
@property(nonatomic, retain) Cardiapp				*cardiapp;

-(IBAction) updateNotes:(id)sender;


@end
```

CardiappViewController.m

```
//
//  CardiappViewController.m
//  Cardiapp
//
//  Created by Shane Courtney on 16/07/2010.
//  Copyright 2010 HealthIT. All rights reserved.
//

#import "CardiappViewController.h"


@implementation CardiappViewController


@synthesize cardiappText;
```

```
@synthesize cardiappStatus;
@synthesize cardiappButton;
@synthesize cardiapp;
@synthesize cardiappBpLabel;
@synthesize cardiappPrLabel;
@synthesize cardiappSao2Label;
@synthesize cardiappWeightLabel;

-(IBAction) updateNotes:(id)sender{
        [self.cardiapp updateNotes:self.cardiappText.text];
}


- (BOOL)textFieldShouldReturn:(UITextView *)textField { // When the return button is pressed on a textField.
        [textField resignFirstResponder]; // Remove the keyboard from the view.
        return YES; // Set the BOOL to YES.
}


- (void)dealloc {
   [super dealloc];
}


@end
```

AddCardiappViewController.h

```
//
//  AddCardiappViewController.h
//  Cardiapp
//
//  Created by Shane Courtney on 24/07/2010.
//  Copyright 2010 HealthIT. All rights reserved.
//

#import <UIKit/UIKit.h>
#import "Cardiapp.h"


#define kSystolic 0
#define kDiastolic 1
#define kPulse 2
#define kSao2 3
#define kWeight 4

// Defining app settings
#define settingsPatientID                @"patientID"
#define settingsPatientWeight            @"weight"
#define settingsPatientSystolic          @"systolic"
#define settingsPatientDiastolic     @"diastolic"
#define settingsPatientPulse             @"pulse"
#define settingsGpNumber                 @"gp"
#define settingsNurseNumber                      @"nurse"
#define settingsNOKNumber                        @"nok"
#define settingsGpEmail                          @"gpemail"
#define settingsNurseEmail               @"nurseemail"



@interface AddCardiappViewController : UIViewController
<UIPickerViewDelegate, UIPickerViewDataSource, MFMessageComposeViewControllerDelegate,
MFMailComposeViewControllerDelegate> {

    IBOutlet UIPickerView            *vitalSignPicker;
    IBOutlet UITextView              *cardiappText;
    IBOutlet UILabel                 *cardiappSystolicLabel;
```

```
	IBOutlet UILabel			*cardiappDiastolicLabel;
	IBOutlet UILabel			*cardiappPrLabel;
	IBOutlet UILabel			*cardiappSao2Label;
	IBOutlet UILabel			*cardiappWeightLabel;
	IBOutlet UILabel			*cardiappStatus;
	IBOutlet UIButton			*cardiappButton;

	// Decalaring array to hold picker values
	NSArray					*systolicArray;
	NSArray					*diastolicArray;
	NSArray					*pulseArray;
	NSArray					*sao2Array;
	NSArray					*weightArray;
	Cardiapp				*cardiapp;

	IBOutlet UIButton			*addNewCardiappButton;

}

@property(nonatomic, retain) IBOutlet UITextView		*cardiappText;
@property(nonatomic, retain) IBOutlet UILabel			*cardiappSystolicLabel;
@property(nonatomic, retain) IBOutlet UILabel			*cardiappDiastolicLabel;
@property(nonatomic, retain) IBOutlet UILabel			*cardiappPrLabel;
@property(nonatomic, retain) IBOutlet UILabel			*cardiappSao2Label;
@property(nonatomic, retain) IBOutlet UILabel			*cardiappWeightLabel;
@property(nonatomic, retain) IBOutlet UILabel			*cardiappStatus;
@property(nonatomic, retain) IBOutlet UIButton			*cardiappButton;
@property(nonatomic, retain) Cardiapp					*cardiapp;

@property(nonatomic, retain) IBOutlet UIPickerView		*vitalSignPicker;
@property(nonatomic, retain) IBOutlet UIButton			*addNewCardiappButton;
@property(nonatomic, retain) NSArray *systolicArray;
@property(nonatomic, retain) NSArray *diastolicArray;
@property(nonatomic, retain) NSArray *pulseArray;
@property(nonatomic, retain) NSArray *sao2Array;
@property(nonatomic, retain) NSArray *weightArray;

-(IBAction) updateCardiapp:(id)sender;

@end
```

AddCardiappViewController.m

```
//  CardiappViewController.m
//  Cardiapp
//
//  Created by Shane Courtney on 16/07/2010.
//  Copyright 2010 HealthIT. All rights reserved.
//

#import "AddCardiappViewController.h"


@implementation AddCardiappViewController


@synthesize cardiappText;
@synthesize cardiappStatus;
@synthesize cardiappButton;
@synthesize cardiapp;
@synthesize cardiappSystolicLabel;
@synthesize cardiappDiastolicLabel;
@synthesize cardiappPrLabel;
@synthesize cardiappSao2Label;
@synthesize cardiappWeightLabel;

@synthesize systolicArray;
@synthesize diastolicArray;
@synthesize pulseArray;
@synthesize sao2Array;
@synthesize weightArray;
@synthesize vitalSignPicker;
@synthesize addNewCardiappButton;

-(IBAction) updateCardiapp:(id)sender{

	NSInteger systolicRowA = [vitalSignPicker selectedRowInComponent:kSystolic];
	NSInteger diastolicRowA = [vitalSignPicker selectedRowInComponent:kDiastolic];
	NSInteger pulseRowA = [vitalSignPicker selectedRowInComponent:kPulse];
	NSInteger sao2RowA = [vitalSignPicker selectedRowInComponent:kSao2];
	NSInteger weightRowA = [vitalSignPicker selectedRowInComponent:kWeight];
```

```
//Setting the new reading to the current date and time

NSDate *dateTitle = [NSDate date];
NSDateFormatter *dateFormatTitle = [[NSDateFormatter alloc] init];
[dateFormatTitle setDateFormat:@"YYYY-MM-dd, hh:mm"];
NSString *dateStringTitle = [dateFormatTitle stringFromDate:dateTitle];



NSString *systolicText = [systolicArray objectAtIndex:systolicRowA];
NSString *diastolicText = [diastolicArray objectAtIndex:diastolicRowA];
NSString *pulseText = [pulseArray objectAtIndex:pulseRowA];
NSString *sao2Text =  [sao2Array objectAtIndex:sao2RowA];
NSString *weightText = [weightArray objectAtIndex:weightRowA];
NSString *message = [[NSString alloc] initWithFormat:
                                                   @"Your Vital Signs readings for %@ have been added
        to the database.  These are as follows: BP %@ %@,  Pulse %@, Sao2 %@ and Weight %@!",
        dateStringTitle, systolicText, diastolicText, pulseText, sao2Text, weightText];

UIAlertView *alert = [[UIAlertView alloc] initWithTitle:
                                          @"Reading taken"
                                          message:message
                                          delegate:nil
                                          cancelButtonTitle:@"OK"
                                          otherButtonTitles:nil];
[alert show];
[alert release];
[message release];


[self.cardiapp updateNotes:self.cardiappText.text];
[self.cardiapp updateSystolic:self.cardiappSystolicLabel.text]; // these will need to be integers!
[self.cardiapp updateDiastolic:self.cardiappDiastolicLabel.text];
[self.cardiapp updatePulse:self.cardiappPrLabel.text];
[self.cardiapp updateSao2:self.cardiappSao2Label.text];
[self.cardiapp updateWeight:self.cardiappWeightLabel.text];
[self.cardiapp updateReading:dateStringTitle];
```

```
//  Reading in the user settings
NSUserDefaults *defaults = [NSUserDefaults standardUserDefaults];
NSString *settingPatientID = [defaults objectForKey:settingsPatientID];

// Send SMS if pateint Systolic is Crticial
NSString *settingGPNumber = [defaults objectForKey:settingsGpNumber];
NSString *settingNurseNumber = [defaults objectForKey:settingsNurseNumber];
NSString *settingNOKNumber = [defaults objectForKey:settingsNOKNumber];

// Send email when primary key
// NSString *settingNurseEmail = [defaults objectForKey:settingsNurseEmail];
// NSString *settingGPEmail = [defaults objectForKey:settingsGpEmail];



// Setting warning SMS Systolic and Diastolic measures.
// If the new Systolic or Diastolic value's entered by pateint is 10 greater than normal then a warning sms will be
// sent to patients nurse, gp and Next of kin.  Again if these values are left blank in setting no sms will be sent.

NSString *settingPatientSystolic = [defaults objectForKey:settingsPatientSystolic];
NSInteger patientSystolicIncreaseLevel = [settingPatientSystolic intValue] + 10;

NSString *settingPatientDiastolic = [defaults objectForKey:settingsPatientDiastolic];
NSInteger patientDiastolicIncreaseLevel = [settingPatientDiastolic intValue] + 10;

// Send SMS to clinician if patient systolic/diastolic is 10 points gretaer than their normal level
// Send SMS to clinician if patient systolic > 140 or Diastolic 100
// Checking first that there is a value in either of the phone numbers in settings file
if (settingGPNumber != NULL || settingNurseNumber != NULL || settingNOKNumber != NULL)
{
   if ([self.cardiappSystolicLabel.text intValue] > patientSystolicIncreaseLevel ||
            [self.cardiappDiastolicLabel.text intValue] > patientDiastolicIncreaseLevel ||
            [self.cardiappSystolicLabel.text intValue] > 140 ||
            [self.cardiappDiastolicLabel.text intValue] > 100)
   {

            MFMessageComposeViewController *controller = [[MFMessageComposeViewController alloc] init];
            controller.messageComposeDelegate = self;

            if([MFMessageComposeViewController canSendText])
            {
                    controller.body = [NSString stringWithFormat:@"Warning SMS.  Patient %@ has recorded a
```

```
high BP value of %@ / %@.  The patients normal BP values are %@ / %@",
                                                    settingPatientID, self.cardiappSystolicLabel.text,
self.cardiappDiastolicLabel.text,
                                                    settingPatientSystolic, settingPatientDiastolic];
                    controller.recipients = [NSArray arrayWithObjects:
settingGPNumber,settingNurseNumber,settingNOKNumber, nil];
                    controller.messageComposeDelegate = self;
                    [self presentModalViewController:controller animated:YES];
                    [controller release];
                }


                MFMailComposeViewController *controllerm = [[MFMessageComposeViewController alloc] init];
                controllerm.mailComposeDelegate = self;

                if ([MFMailComposeViewController canSendMail]){

                    controllerm.Subject:@"Patient Readings!";
                    [controllerm setMessageBody:@" Shane Testing this email" isHTML:NO];
                    [controllerm setToRecipients:[NSArray arrayWithObjects: settingNurseEmail,
settingGPEmail, nil]];
                    controllerm.mailComposeDelegate = self;
                    [self presentModalViewController:controllerm animated:YES];
                    [controllerm release];
                }

            }
        }

        // Send SMS if pateint has a weight incease of 2 kgs
        NSString *settingPatientWeight = [defaults objectForKey:settingsPatientWeight];
        NSInteger patientWeightIncreaseLevel = [settingPatientWeight intValue] +2;

        if ([self.cardiappWeightLabel.text intValue] > patientWeightIncreaseLevel){

            MFMessageComposeViewController *controller = [[[MFMessageComposeViewController alloc] init]
autorelease];
            controller.messageComposeDelegate = self;

            if([MFMessageComposeViewController canSendText])
            {
                controller.body = [NSString stringWithFormat:@"Warning SMS.  Patient %@ has recorded a  weight
```

```
increased from %@ KGs to %@ KGs",
                                                            settingPatientID, settingPatientWeight,
self.cardiappWeightLabel.text];
                    controller.recipients = [NSArray arrayWithObjects:@"00353879315430", nil];
                    controller.messageComposeDelegate = self;
                    [self presentModalViewController:controller animated:YES];

          }
        }
}



- (void)pickerView:(UIPickerView *)pickerView didSelectRow:(NSInteger)row inComponent:(NSInteger)component { //
And now the final part of the UIPickerView, what happens when a row is selected.

        NSInteger systolicRow = [vitalSignPicker selectedRowInComponent:kSystolic];
        NSInteger diastolicRow = [vitalSignPicker selectedRowInComponent:kDiastolic];
        NSInteger pulseRow = [vitalSignPicker selectedRowInComponent:kPulse];
        NSInteger sao2Row = [vitalSignPicker selectedRowInComponent:kSao2];
        NSInteger weightRow = [vitalSignPicker selectedRowInComponent:kWeight];

        cardiappSystolicLabel.text = [systolicArray objectAtIndex:systolicRow];
        cardiappDiastolicLabel.text = [diastolicArray objectAtIndex:diastolicRow];
        cardiappPrLabel.text = [pulseArray objectAtIndex:pulseRow];
        cardiappSao2Label.text = [sao2Array objectAtIndex:sao2Row];
        cardiappWeightLabel.text = [weightArray objectAtIndex:weightRow];

}


// Loading the pickers with values
- (void)viewDidLoad {

        // Filling the Systolic Array
        NSMutableArray *fillingSystolicArray = [[NSMutableArray alloc] initWithCapacity:100];
        for ( int i = 0 ; i <= 200 ; i ++ )
          [fillingSystolicArray addObject:[[NSNumber numberWithInt:i]stringValue]];

        self.systolicArray = fillingSystolicArray;
        [fillingSystolicArray release];
```

```
// Filling the Diastolic Array [NSNumber numberWithInt:i]];
NSMutableArray *fillingDiastolicArray = [[NSMutableArray alloc] initWithCapacity:100];
for ( int i = 0 ; i <= 140 ; i ++ )
  [fillingDiastolicArray  addObject:[[NSNumber numberWithInt:i]stringValue]];

self.diastolicArray = fillingDiastolicArray;
[fillingDiastolicArray  release];

// Filling the Pulse Array
NSMutableArray *fillingPulseArray = [[NSMutableArray alloc] initWithCapacity:100];
for ( int i = 0 ; i <= 140 ; i ++ )
  [fillingPulseArray  addObject:[[NSNumber numberWithInt:i]stringValue]];

self.pulseArray = fillingPulseArray;
[fillingPulseArray  release];

// Filling the sao2 Array
NSMutableArray *fillingSao2Array = [[NSMutableArray alloc] initWithCapacity:100];
for ( int i = 0 ; i <= 100 ; i ++ )
  [fillingSao2Array  addObject:[[NSNumber numberWithInt:i]stringValue]];

self.sao2Array = fillingSao2Array;
[fillingSao2Array  release];

// Filling the Weight Array
NSMutableArray *fillingWeightArray = [[NSMutableArray alloc] initWithCapacity:100];
for ( int i = 0 ; i <= 300 ; i ++ )
  [fillingWeightArray  addObject:[[NSNumber numberWithInt:i]stringValue]];
self.weightArray = fillingWeightArray;
[fillingWeightArray  release];

// Taking patient settings from setting file to populate the pickers

NSUserDefaults *defaults = [NSUserDefaults standardUserDefaults];


NSString *settingPatientSystolic = [defaults objectForKey:settingsPatientSystolic];
NSInteger patientSystolicLevel = [settingPatientSystolic intValue];
[vitalSignPicker selectRow:patientSystolicLevel inComponent:0 animated:NO];

NSString *settingPatientDiastolic = [defaults objectForKey:settingsPatientDiastolic];
```

```
        NSInteger patientDiastolicLevel = [settingPatientDiastolic intValue];
        [vitalSignPicker selectRow:patientDiastolicLevel inComponent:1 animated:NO];

        NSString *settingPatientPulse = [defaults objectForKey:settingsPatientPulse];
        NSInteger patientPulseLevel = [settingPatientPulse intValue];
        [vitalSignPicker selectRow:patientPulseLevel inComponent:2 animated:NO];

        [vitalSignPicker selectRow:100 inComponent:3 animated:NO];

        NSString *settingPatientWeight = [defaults objectForKey:settingsPatientWeight];
        NSInteger patientWeightLevel = [settingPatientWeight intValue];
        [vitalSignPicker selectRow:patientWeightLevel inComponent:4 animated:NO];

}


- (void)messageComposeViewController:(MFMessageComposeViewController *)controller
didFinishWithResult:(MessageComposeResult)result
{
        switch (result) {
          case MessageComposeResultCancelled:
                    NSLog(@"Cancelled");
                    break;
          case MessageComposeResultSent:
                    break;
          default:
                    break;
        }

        [self dismissModalViewControllerAnimated:YES];
}
- (void)dealloc {
        [systolicArray release];
        [diastolicArray release];
        [pulseArray release];
        [sao2Array release];
        [weightArray release];
        [vitalSignPicker release];
        [super dealloc];
}

#pragma mark -
```

```
#pragma mark Picker delegate methods

-(NSInteger) numberOfComponentsInPickerView:(UIPickerView *)pickerView
{
	return 5;
}

-(NSInteger)pickerView:(UIPickerView *)pickerView
numberOfRowsInComponent:(NSInteger)component
{
	if (component == kSystolic)
	   return [self.systolicArray count];

	else if (component == kDiastolic)
	   return [self.diastolicArray count];

	else if (component == kPulse)
	   return [self.pulseArray count];

	else if (component == kSao2)
	   return [self.sao2Array count];

	else return [self.weightArray count];

}

#pragma mark Picker Delegate Method

-(NSString *)pickerView:(UIPickerView *)pickerView
                titleForRow:(NSInteger) row
           forComponent:(NSInteger)component
{
	if (component == kSystolic)
	   return [self.systolicArray objectAtIndex:row];

	else if (component == kDiastolic)
	   return [self.diastolicArray objectAtIndex:row];

	else if (component == kPulse)
	   return [self.pulseArray objectAtIndex:row];

	else if (component == kSao2)
```

```
        return [self.sao2Array objectAtIndex:row];

    else return [self.weightArray objectAtIndex:row];
}

@end
```

RPMapp Settings File


```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE plist PUBLIC "-//Apple//DTD PLIST 1.0//EN" "http://www.apple.com/DTDs/PropertyList-1.0.dtd">
<plist version="1.0">
<dict>
	<key>Title</key>
	<string>AppSettings</string>
	<key>StringsTable</key>
	<string>Root</string>
	<key>PreferenceSpecifiers</key>
	<array>
		<dict>
			<key>Type</key>
			<string>PSGroupSpecifier</string>
			<key>Title</key>
			<string>Patient General Info</string>
		</dict>
		<dict>
			<key>Type</key>
			<string>PSTextFieldSpecifier</string>
			<key>Title</key>
			<string>PatientID</string>
			<key>Key</key>
			<string>patientID</string>
			<key>AutocapitalizationType</key>
			<string>None</string>
			<key>AutocorrectionType</key>
			<string>No</string>
		</dict>
		<dict>
			<key>Type</key>
```

```
		<string>PSTextFieldSpecifier</string>
		<key>Title</key>
		<string>Weight</string>
		<key>Key</key>
		<string>weight</string>
		<key>AutocapitalizationType</key>
		<string>None</string>
		<key>AutocorrectionType</key>
		<string>No</string>
		<key>IsSecure</key>
		<true/>
	</dict>
	<dict>
		<key>Type</key>
		<string>PSTextFieldSpecifier</string>
		<key>Title</key>
		<string>Systolic</string>
		<key>Key</key>
		<string>systolic</string>
		<key>AutocapitalizationType</key>
		<string>None</string>
		<key>AutocorrectionType</key>
		<string>No</string>
		<key>IsSecure</key>
		<true/>
	</dict>
	<dict>
		<key>Type</key>
		<string>PSTextFieldSpecifier</string>
		<key>Title</key>
		<string>Diastolic</string>
		<key>Key</key>
		<string>diastolic</string>
		<key>AutocapitalizationType</key>
		<string>None</string>
		<key>AutocorrectionType</key>
		<string>No</string>
		<key>IsSecure</key>
		<true/>
	</dict>
	<dict>
		<key>Type</key>
```

```
		<string>PSTextFieldSpecifier</string>
		<key>Title</key>
		<string>Pulse</string>
		<key>Key</key>
		<string>pulse</string>
		<key>AutocapitalizationType</key>
		<string>None</string>
		<key>AutocorrectionType</key>
		<string>No</string>
		<key>IsSecure</key>
		<true/>
	</dict>
	<dict>
		<key>Type</key>
		<string>PSGroupSpecifier</string>
		<key>Title</key>
		<string>AlertSMS</string>
	</dict>
	<dict>
		<key>Type</key>
		<string>PSTextFieldSpecifier</string>
		<key>Title</key>
		<string>GP</string>
		<key>Key</key>
		<string>gp</string>
		<key>AutocapitalizationType</key>
		<string>None</string>
		<key>AutocorrectionType</key>
		<string>No</string>
		<key>IsSecure</key>
		<true/>
	</dict>
	<dict>
		<key>Type</key>
		<string>PSTextFieldSpecifier</string>
		<key>Title</key>
		<string>Nurse</string>
		<key>Key</key>
		<string>nurse</string>
		<key>AutocapitalizationType</key>
		<string>None</string>
		<key>AutocorrectionType</key>
```

```
		<string>No</string>
		<key>IsSecure</key>
		<true/>
	</dict>
	<dict>
		<key>Type</key>
		<string>PSTextFieldSpecifier</string>
		<key>Title</key>
		<string>NOK</string>
		<key>Key</key>
		<string>nok</string>
		<key>AutocapitalizationType</key>
		<string>None</string>
		<key>AutocorrectionType</key>
		<string>No</string>
		<key>IsSecure</key>
		<true/>
	</dict>
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