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PhD THESIS

Healthcare4Life: A Ubiquitous Patient-Centric Telehealth System

Jaspaljeet Singh Ranjit Singh

A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Computer Science

The University of Auckland
December 2013
Abstract

Over the past decade, healthcare costs and especially senior healthcare costs have increased rapidly and are making traditional healthcare concepts unaffordable for many developed countries. Telehealth is thought to be a solution for effective senior healthcare. However, existing telehealth systems are focused on treating diseases instead of preventing them, suffer from high initial costs, and lack extensibility. They also do not address the social and psychological needs of the patients.

In this thesis, a novel patient-centric telehealth system for seniors called Healthcare4Life is presented and evaluated. The system provides access to a variety of health-related applications, which encourage positive lifestyle changes. Users are able to locate other users or patients suffering from similar diseases, enabling them to share experiences, motivate each other, and engage in health-related activities, such as tracking physical activities and vital signs. Similar to Facebook, the system has an open architecture that enables third-party providers to add new content and functionalities.

User requirements of Healthcare4Life were elicited via interviews conducted with potential users. Web 2.0 technologies are evaluated with regard to their suitability for the development of extendable telehealth systems with social networking capabilities. Based on these findings, a system prototype is developed and evaluated. A formative evaluation approach is presented, confirming that seniors are satisfied with the overall concept and usability. A summative evaluation conducted with support from senior community centres with a larger sample size is presented, demonstrating the overall feasibility and acceptability of the system.

The results demonstrate that the combination of telehealth functionalities with social components and user-generated content is a promising way to enable users to proactively manage and improve their health. However, the results suggest that in order to be useful in practice the system needs a large user base and must offer services making it attractive to application developers and content providers. Web standards, such as OpenSocial, and a content management system, such as Drupal, integrate successfully and provide a foundation to convert ordinary systems into open-ended platforms. The evaluation indi-
icates that the target user population, seniors, were keen to leverage Healthcare4Life for their healthcare, provided there is a range of health applications tailored towards individual needs. Social networking functionalities are desired, but should have a clear purpose such as social games or exchanging information, rather than broadcasting emotions and opinions. Results further suggest that web-based telehealth systems hold great potential to positively change the attitude of users that health is not controlled by others such as health professionals, but consumers have the power to positively affect their well-being.
This thesis is dedicated to my brother, Kamaljit Singh Dhillon, whom I last saw before leaving for Auckland to pursue my PhD.

Kamal, your passing left a heartache that nobody can heal, but your love left memories that nobody can steal. I thank you for your unconditional love and support, and all the unforgettable memories. You have been a source of motivation and inspiration and will always be.
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I hereby wish to express my gratitude to the following people who enabled this thesis to be successfully and timeously completed.

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My special thanks are extended to the seniors who participated in the user studies of this research for their kind support, patience and valuable feedback, without your willingness and commitment this project would never have got off the ground. I am particularly grateful for the assistance given by Noel Mendoza from WellingtonICT and Ray McDonald from SeniorNet Eden-Roskill for advertising the final evaluation study and for allowing us to use their premises to conduct the introductory sessions. I would like to offer my special thanks to Noel Mendoza for his feedback on the study plan and the overall concept. Advice given by Dr. Nilufar Baghaei has been a great help in conducting the final evaluation study and I look forward to working with her in the near future. Special thanks to Beverly Fairfax for helping me to proofread the user guideline that was prepared for the final study.

I wish to acknowledge the management of Universiti Tenaga Nasional in Malaysia for sponsoring me to do my PhD in New Zealand, including their support and encouragement for both my family and me. Without their support, I would not have had the courage to embark on this journey in the first place.

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## Glossary

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<tr>
<td>AJAX</td>
<td>Asynchronous JavaScript and XML</td>
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<tr>
<td>API</td>
<td>Application Programming Interface</td>
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<tr>
<td>BMI</td>
<td>Body Mass Index</td>
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<tr>
<td>BP</td>
<td>Blood pressure</td>
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<tr>
<td>CCK</td>
<td>Content Construction Kit</td>
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<td>CMS</td>
<td>Content Management System</td>
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<tr>
<td>CSS</td>
<td>Cascading Style Sheets</td>
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<tr>
<td>FBJS</td>
<td>Facebook JavaScript</td>
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<tr>
<td>FBML</td>
<td>Facebook Markup Language</td>
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<tr>
<td>FQL</td>
<td>Facebook Query Language</td>
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<tr>
<td>HC4L</td>
<td>Healthcare4Life</td>
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<tr>
<td>HCI</td>
<td>Human Computer Interaction</td>
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<tr>
<td>HTML</td>
<td>HyperText Markup Language</td>
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<tr>
<td>IBM</td>
<td>International Business Machines Corporation</td>
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<tr>
<td>IMI</td>
<td>Intrinsic Motivation Inventory</td>
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<tr>
<td>JSON</td>
<td>JavaScript Object Notation</td>
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<tr>
<td>KDP</td>
<td>Key Design Principle</td>
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<tr>
<td>MET</td>
<td>Metabolic Equivalent of Task</td>
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<td>MLHC</td>
<td>Multidimensional Health Locus of Control</td>
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<td>MVC</td>
<td>Model View Controller</td>
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<td>OAuth</td>
<td>Open Authentication</td>
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<td>OOP</td>
<td>Object Oriented Programming</td>
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<tr>
<td>PDA</td>
<td>Personal Digital Assistant</td>
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<tr>
<td>PHP</td>
<td>PHP: Hypertext Preprocessor</td>
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<td>REST</td>
<td>Representational State Transfer</td>
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<td>RPC</td>
<td>Remote Procedure Call</td>
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<tr>
<td>SAP</td>
<td>Systems, Applications, and Products in Data Processing</td>
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<tr>
<td>SPI</td>
<td>Service Provider Interface</td>
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<tr>
<td>SD</td>
<td>Standard Deviation</td>
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<td><strong>STRRIDE</strong></td>
<td>Studies of a Targeted Risk Reduction Intervention Through Defined Exercise</td>
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<tr>
<td><strong>SUS</strong></td>
<td>System Usability Scale</td>
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<tr>
<td><strong>URL</strong></td>
<td>Uniform Resource Locator</td>
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<tr>
<td><strong>WAF</strong></td>
<td>Web Application Framework</td>
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<tr>
<td><strong>XML</strong></td>
<td>Extensible Markup Language</td>
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<td>Czarina Ramos</td>
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1. Introduction

Over the past decade healthcare costs have risen faster than government expenditure in most developed countries. Various telehealth solutions have been proposed to make healthcare services more widely available, efficient, and cost-effective. Current telehealth systems are mostly confined to health monitoring in a home environment. Adoption and use is further constrained by the high initial costs, the lack of extensibility, and a system design which is centred around the clinical users. A novel telehealth solution is necessary to overcome these shortcomings.

In this thesis, we critically analyse existing consumer health informatics systems and propose a framework for overcoming the identified shortcomings. We develop a prototype of a system which is ubiquitous, extendable by third parties, contains social aspects, and puts the user in control. We evaluate the system’s usability and functionalities, demonstrate advantages over previous approaches, and identify limitations and possible ways to overcome them.

Section 1.1 provides a background for this research and motivates it. Research goals and the corresponding objectives are presented in Section 1.2. Section 1.3 summarises the approach taken to conduct this research. Section 1.4 gives a breakdown of the thesis chapters and its content.

1.1. Background and Motivation

The healthcare systems in many developed countries are rapidly approaching a crisis point due to an ever increasing demand for healthcare interventions and a serious demographic change. According to the World Health Organization (2009), globally, the number of persons aged 60 and over is expected almost to triple, increasing from 739 million in 2009 to 2 billion by 2050. Furthermore, the support ratio for people aged 65 and over is predicted to fall from 9:1 in 2009 to 4:1 in 2050 (United Nations, 2009). This means that there will be fewer people to look after the seniors in the future.

Moreover, Machlin (2009) reports that the annual healthcare expenditure for seniors is
Chapter 1

Introduction

rising rapidly. At the same time, there is a worldwide shortage of healthcare professionals (World Health Organization, 2006) and an increasing strain on public finances, making the cutting of entitlement spending such as healthcare virtually unavoidable (International Monetary Fund, 2009). The problem is compounded by the fact that seniors are more often affected by chronic diseases which require ongoing, often expensive treatment (CDC, 2011). An extensive five-country study by Edelman (2009) found three emerging issues concerning public health including: providing access to affordable healthcare, solving chronic health problems and preventing disease.

A potential avenue to address these challenges is to empower health consumers to take control of their own health. Research indicates that active participation of patients in their healthcare improves health outcomes (Hibbard and Cunningham, 2008, Weitzel et al., 2009). If patients play an active role in preventing diseases instead of being passive recipients of treatments after getting sick, they will be able to take better control of their health. Cost-saving transformation in healthcare can be achieved by shifting our focus from clinician-based systems to consumer-based personal wellness systems deployed ubiquitously (Dishman, 2004).

Home-based healthcare applications such as telehealth can enable users to track their health status and to actively participate in treatment regimens and preventive strategies. The Health Resources and Services Administration (HRSA, 2013), an agency of the U.S. Department of Health and Human Services, defines telehealth as: “the use of electronic information and telecommunications technologies to support long-distance clinical healthcare, patient and professional health-related education, public health, and health administration.”

From the above definition, it is clear that telehealth is broadly about receiving care from a distance. Research suggests that seniors generally prefer to age independently in their own homes than moving to an institutional care setting (Koch, 2006, Botsis et al., 2008). Telehealth meets the preference of seniors to remain at their own homes and could therefore be a viable solution enabling patients to take charge of their own health.

However, we argue that in order to impact overall healthcare spending, such systems must be widely available, affordable, extendable and most importantly their design should reflect the needs of the “patients”. Existing telehealth systems are mostly doctor-centric, enabling health professionals to remotely perform clinical, educational or administrative tasks. Arguably the most common application is the management of chronic diseases by remote monitoring. It has been shown that remote monitoring is able to achieve cost savings (Wade et al., 2010), and has been a focus of commercial development. However,
Currently available commercial monitoring solutions concentrate on managing diseases rather than preventing them. These solutions are typically not web-based, but are standalone systems with limited functionality. They suffer from vendor lock-in, i.e. cannot be extended by third parties, and require extra costs to add new functionalities. Patients are mainly an information source of health parameters. Current systems do not encourage patients to take preventive actions, and do not take into account their social and psychological needs (Lee et al., 2011a). Further details about current telehealth systems are provided in Section 2.1 on page 11.

Internet-based solutions are promising interventions that could bring desired lifestyle changes and are capable of reaching a wider section of the senior population at a low cost (Aalbers et al., 2011). Over the years, the Web has evolved from supporting health information seeking to support health-motivated social communication. Jones and Fox (2009) state that the fastest growth in Internet use is being driven by the older age groups, starting at 55. Recent Internet demographics trends from the Pew Research Center, reported by Zickuhr and Madden (2012), suggest that more than half (53%) of U.S. seniors are online today (see Figure 1.1). Searching for health-related information is the third most popular online activity, after email and online search in general (Zickuhr, 2010). The continued growth in the number of seniors going online indicates an increased utilisation of web-based resources (Kahana et al., 2011), which provides opportunities to address the shortcomings of current telehealth systems.

Figure 1.1.: Internet usage of American adults by age group. More than half of all seniors in the USA now use the Internet (from Zickuhr and Madden, 2012).

The emergence of Web 2.0 technology holds great potential to develop modern, sophis-
ticated and effective health applications that could improve health outcomes and complement healthcare delivery. Existing Web 2.0 health applications and services (also known as Health 2.0) are rapidly gaining attention from patients and professionals, as they extend traditional healthcare delivery models, empower patient self-care and provide social support. For instance, PatientsLikeMe.com, a popular website that has more than 150,000 registered patients and exceeding 1,000 conditions, provides access to valuable medical information aggregated from a large number of patients experiencing similar diseases. Wicks et al. (2010) indicate that there is a range of benefits from sharing health data online including the potential of improving “disease self-management”. In general, existing Web 2.0 health applications are known to provide useful functionalities such as diet and exercise monitoring, and formation of support groups. However, most of these applications are expensive, do not offer a comprehensive suite of functionalities, target often younger health consumers, and do not replace traditional telehealth platforms. Section 2.3 on page 17 offers more detailed information about Web 2.0 health applications.

1.2. Research Aims and Objectives

The principle aim of this thesis is to develop and test new concepts to address the aforementioned shortcomings of current telehealth systems and Web 2.0 health applications. The idea is to design a framework for a ubiquitous patient-centric telehealth system with social aspects, develop a prototype implementing key concepts, and explore these concepts using the prototype. The system aims to enable seniors to take control of their health by changing their attitude towards health management. The following list is a breakdown of the principle aim into a series of objectives:

1. To establish the user requirements for a patient-centric telehealth system.
   a) Evaluate consumer health informatics applications from a patient perspective and to analyse their strengths and weaknesses.
   b) Investigate barriers which prevent seniors from making effective use of telehealth systems.

2. To design and implement a novel “web-based” telehealth system which addresses the identified shortcomings.
   a) Design a conceptual framework to identify components and requirements.
1.2 Research Aims and Objectives

b) Evaluate web-technologies for implementing a web-based patient-centric tele-health system.

c) Implement a prototype of a plug-in architecture enabling third-party providers to add new applications.

d) Develop simple applications, e.g. for monitoring, education and visualisation, and test them within the plug-in architecture.

e) Investigate the integration of social networking features.

3. To evaluate the usability of the new system and get some insight into its effectiveness.

a) Identify and resolve (where possible) the usability issues faced by potential system users.

b) Identify how the system changes user’s attitude towards personal healthcare. (A clinical evaluation of the new system will be outside the scope of this thesis.)

The newly developed system is called Healthcare4Life (hereafter referred to as HC4L). Our evaluation of existing technologies will show that the new system should be ubiquitous, extendable by third parties, contain social aspects, encourage cognitive engagement, and put the user in control. Further details about the system design and features can be found in Chapter 5 and 7. We have called our system “Healthcare4Life” as it refers to health in general and is not confined to particular diseases or health conditions. The idea is to design a system that is capable of hosting a wide variety of health applications to address the health needs and expectations of health consumers. We envision the system to support health consumers with preventing diseases and to become more involved in the control and cure of existing conditions. Hence, the involvement of clinicians is not emphasised. However, the users are advised to contact their healthcare providers if unusual patterns in the monitored health indicators are detected.

Ideally, HC4L should be open for anyone to use, but in this thesis, the focus is on seniors. We use the terminology employed by the United Nations, which uses the term “seniors” for people of age 60 and above (World Health Organization, n.d.). Terms like “elderly” or “elders” were avoided due to the negative associations or stigmatisation (e.g. frail, dependent and lonely) attached to such terms. We are interested in targeting this user population due to the general fact that seniors need more support for managing their
healthcare independently and they are disproportionately more affected by chronic diseases than the younger generation. Furthermore, although much work has been done on meeting the health requirements of seniors, there is still a lack of knowledge about their technology needs and how a system should be best designed (Koch and Hägglund, 2009).

### 1.3. Methodology

As mentioned above, HC4L is mainly intended for use by seniors. Heart and Kalderon (2011) reported that seniors will only use a computer-based health intervention if they are convinced that such technology will benefit them. This implies the necessity of involving potential users of our system in the entire design process to ensure that the intervention meets their requirements and preferences. Furthermore, the involvement of end-users in the design and development process facilitates successful implementation and utilisation (Tsianakas et al., 2012), which could help to increase user satisfaction and enhance the perception of usefulness of the system.

Therefore, we have employed a patient-centric approach in developing HC4L by working closely with seniors from the outset. Several studies were conducted with representatives of this target user population in meeting our research objectives laid out in Section 1.2. Although the research was mostly interpretivist, the quantitative and qualitative methods were adopted in the data gathering process. The operational framework suggested by Arsand and Demiris (2008) and depicted in Figure 1.2 was used as guidance for involving end-users in the system design process. An overview about the steps involved in this project is provided below.

Initially, user needs were identified by investigating the shortcomings of existing consumer health informatics applications. Based on this, a conceptual framework of our solution (i.e. HC4L) was developed and its feasibility based on existing technologies was explored. A literature survey was conducted to identify usability problems of past and current telehealth systems. This information was used to formulate the general requirements of seniors towards novel telehealth systems. Semi-structured interviews were also administered with a group of seniors to elicit their expectations as well as the functional and user interface requirements of HC4L. The conceptual framework and information gathered from the interview study drived the design decisions of the system and a functional prototype of HC4L was developed accordingly. The first version of the system was evaluated by a group of seniors. Feedback and suggestions received were used to refine the system.
1.4. Structure of the Thesis

In order to achieve the research objectives set out in Section 1.2, the thesis is organised into ten chapters. Each chapter relates to one or more of the stated research objectives. Broadly, this thesis can be divided into four parts (see Table 1.1 on the next page). The first part consists of this chapter and Chapter 2, and motivates this research and provides background information necessary for the understanding of this thesis. The second part consists of Chapter 3 and 4, and discusses requirements for the development of HC4L based on related work and user studies. The design and development of the system are demonstrated in the third part of this work which comprises Chapter 5 to 7. The fourth part comprises Chapter 8 and 9, and presents the evaluation of the system.

Chapter 2 reviews a range of popular consumer health informatics applications which are commercially available to consumers to assist with managing their health. The chapter provides an overview of each application category and discusses shortcomings and successful concepts. This chapter highlights the research gap and explains why there is a need for a more generic and patient-centric telehealth system.

Chapter 3 describes a taxonomy of usability requirements and design concepts for home telehealth systems. The taxonomy is developed to address the common problems faced by
Chapter 4 discusses the specific requirements to develop a web-based telehealth system targeted towards seniors. Although we have captured a holistic picture of the general requirements from Chapter 3, it is essential to determine seniors’ expectations and perceptions towards web-based healthcare solutions. This chapter presents the functional and user interface requirements that were obtained via semi-structured interviews conducted with potential users of HC4L. Several screenshots of existing web-based health applications and a paper-based prototype of HC4L were used to facilitate the interviews.

Chapter 5 describes the general design principles and a conceptual framework of HC4L. The conceptual framework provides a complete view of the solution suggested to overcome shortcomings of present consumer health informatics applications. This chapter also presents the design of a prototype that was developed to assess the overall concept, content, and its feasibility with seniors.

Chapter 6 evaluates popular Web 2.0 technologies for developing a web-based telehealth system. It discusses the capabilities of popular social networking APIs (Application Programming Interfaces) and web development tools that aided the selection of technologies to implement the features described in Chapter 5. It justifies the choice of technology used, OpenSocial and Drupal CMS, for the development of our HC4L prototype.

Chapter 7 provides implementation details of HC4L. It describes how HC4L was turned

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into an open platform that allows third-party developers to contribute content. Essentially, it includes details about how the OpenSocial API and Drupal was integrated to realise HC4L. This chapter also presents the implementation issues and challenges of leveraging the aforementioned technologies in the development of HC4L.

Chapter 8 presents a formative evaluation of HC4L - a study conducted with a group of seniors to assess the usability and functionalities of the system. The objective was to identify any design issues as well as to receive feedback from potential users. Identified usability issues and suggestions from the study participants were used to improve HC4L accordingly, before it was tested with a large number of users.

Chapter 9 provides details of a summative evaluation of HC4L, which was a longitudinal study conducted with a large sample of seniors. Instrumentation used in the assessment of the concept and prototype of HC4L incorporated existing well established scales. Implications of the results obtained are presented.

Chapter 10 summarises findings and draw conclusions from the research presented in the preceding chapters. It describes how well each of the aims and objectives of this study have been fulfilled and discusses the limitations of the research. The chapter also provides several ideas for future research.
2. Consumer Health Informatics Applications

The preceding chapter has motivated the need for more healthcare interventions that will enable health consumers, especially seniors, to manage or improve their health from home. Over recent years an increasing number of healthcare applications have been developed, including consumer health informatics applications that are designed to interact directly with consumers, with or without the presence of healthcare professionals (Eysenbach, 2000). In this chapter, we evaluate a range of common consumer health informatics applications from the patient’s perspective and discuss their strengths and weaknesses for healthcare. The aim is to identify shortcomings and successful concepts to motivate the design of HC4L.

The following four sections (Section 2.1 to Section 2.4) review and analyse consumer health informatics applications. Section 2.5 discusses the results. Parts of this chapter were published in Singh et al. (2010a) and Dhillion et al. (2011a).

2.1. Telehealth Systems

Telehealth systems are known to increase access to healthcare services. They enable healthcare providers to deliver remote care and monitoring services to patients in their homes (see Figure 2.1). These systems can employ both synchronous (real time) and asynchronous (such as store and forward) technologies (McLean et al., 2011) to enable the patient-doctor communication loop to take place (see Figure 2.2). Synchronous systems achieve real-time interactions by using the phone or videoconferencing. Asynchronous communication refers to delayed analysis and feedback according to patient priorities, and are typically provided via email or telephone by the healthcare provider.

Telehealth systems are most commonly employed for patients with chronic diseases where regular vital sign monitoring, such as heart rate, blood pressure, or weight, is necessary. The data can be input manually (see Figure 2.3) or recorded automatically using...
Bluetooth enabled monitoring devices. The patient’s health parameters and answers to user specific monitoring questions are transmitted to the system’s backend. The system’s clinical interface allows the care providers to check individual patient data using a graphical display of time series data, or to monitor an entire cohort by displaying patient alerts sorted by priority (e.g. monitoring data outside the permissible range). Telehealth systems are very useful, however, they cannot operate in all clinical settings as they are unable to capture certain health parameters. For instance, as indicated by Harnett (2006), in psychiatric assessments, observations of posture, speech and mental state are required.

The leading providers of telehealth systems make use of standalone applications with specialised hardware (see Figure 2.4) and incorporate a wide range of features to increase applicability of their systems. LifeView Patient Station by American TeleCare Inc. (ATI) (americantelecare.com) combines video telehealth and remote patient monitoring, which allows clinicians to monitor patients’ health status, identify instabilities, and provide real time remote clinical intervention to re-stabilise patients. Tunstall’s telehealth monitors (tunstall.co.uk) are very compact and contain just a few buttons similar to a simple game controller. The monitors support a wide range of languages, allow clinical users to define questions tailored to patient’s health condition, and offer adjustable font sizes. Docobo’s HealthHub (docobo.co.uk) resembles a PDA (Personal Digital Assistant) and uses the principle of “store and forward”. Vital signs measurements and changes in symptoms, side effects, lifestyle and quality of life are securely recorded and transferred to the centre of care. The patient can track their main health parameters (such as weight, blood pressure, medication compliance) via a four week trend display.
2.1. Benefits of Telehealth Systems

One of the primary benefits of telehealth systems is the ability to reach underserved sections of the population, especially those in remote and rural areas (Loane and Wootton, 2001). The remote monitoring of vital signs assists management of chronic conditions and enables tailored care, which improves patients’ quality of life and reduces hospital admissions (Darkins et al., 2008). Telehealth enables patients to remain at their own homes while giving them and their family peace of mind knowing that monitoring and help is available. This is important since research suggests that patients prefer to self-manage their health and to “age in place” rather than in an institution (Koch, 2006). In addition, Onor et al. (2008) indicate that the satisfaction of seniors living at home using telehealth is significantly higher compared to residents of daycare centres or nursing homes.

Telehealth enables individuals to perform most of the measurements conducted at the primary healthcare provider themselves, thereby reducing doctor visits and the resulting travel stress, waiting times and associated costs (Loane and Wootton, 2001). Patient monitoring data is sent electronically and the clinician carer/doctor can check the data at the office thereby freeing up time for conducting more detailed examinations or for seeing more patients (Johnston et al., 2000). Therefore, home nursing conducted remotely via telehealth can lead to a more efficient use of resources.

Figure 2.2.: Key elements of telehealth (from McLean et al., 2011).
2.1.2. Challenges of Telehealth Systems

Although there are many advantages of implementing telehealth solutions, there are limiting factors. The insurers’ reluctance to pay for telehealth services is regarded as one of the main obstacles to total integration of telehealth into healthcare practice (Field and Grigsby, 2002). The reimbursement issues of telehealth remain unresolved and are complicated by conflicting evidence of its cost effectiveness (Wootton, 2009). Proper cost analysis is impeded by the rapid advancement of telehealth technology (Loane and Wootton, 2001).

The second limiting factor is the fact that telehealth systems are used as part of the formal healthcare system. Dishman (2004) indicated that the clinicians owe the same duty of care as with conventional forms of delivery and must be kept “in the loop”. This necessitates commitment of practitioners to diagnose and suggest treatment to the patients,
2.2 Health Record Management Systems (HRMS)

which limits involvement of the patient and third-party providers. Therefore, telehealth requires substantial organisational change in order to be effective (Loane and Wootton, 2001). Furthermore, some clinicians are less receptive to the use of these new technologies (Field and Grigsby, 2002).

Baker (2006) reported that most telehealth systems available for consumers are expensive and difficult to operate. Although they provide financial benefits with increased duration of care (Dansky et al., 2001), the set up cost is high. Since the systems require operation by patients or their family, usability and technical support are important concerns (Botsis et al., 2008).

Furthermore, Chan et al. (2008) report that home nursing reduces the close contact and resulting trust between care recipient and provider. The clinician might not obtain the same information as in a face-to-face consultation. The inability to touch the patient may hinder clinical decisions and some patients are concerned over the lack of physical presence of a medical professional (Rahimpour et al., 2008). Some patients, especially those living alone, value the social contact with their practitioners.

In the U.S.A. there is a concern over the liability and medical licensure for physicians providing telehealth services to patients residing in another state. The licensure is an ongoing issue and most existing telehealth services are not offered across state lines (Field and Grigsby, 2002). Different countries or states seem to have varying legislation (Chan et al., 2008).

2.2. Health Record Management Systems (HRMS)

A personal health record (PHR) is an electronic application through which individuals can access, manage and share their health information. PHRs are not the same as electronic health records (EHRs), which are controlled by the healthcare provider (Zuckerman and Kim, 2009). PHRs provide patients with better access to their healthcare data and enable them to be stewards of this information (Halamka et al., 2008). Users can record a wide range of health-related data such as allergies, results of laboratory tests (e.g. X-ray), illnesses, and hospitalisations. According to Endsley et al. (2006), PHRs can be classified into three categories: (1) a provider-owned and maintained digital summary of relevant health information made available to patients; (2) a patient-owned software program that lets individuals manage their health information; and (3) a portable, interoperable digital file storing the health data. Platforms for portable PHRs include smart cards, PDAs, cellular phones and USB drives. The data in PHR can be stored by the patient (manually
or via uploading a file) or it could be updated automatically if tethered to an EHR (Tang et al., 2006).

There has been increasing interest in the development and adoption of PHRs by employers, professional health groups, government agencies, and major software organisations. In 2007 Google and Microsoft started creating their own free or subscription-based online health record applications (Lohr, 2007). But Google withdrew Google Health in June 2011 (Andrews, 2011).

### 2.2.1. Benefits of HRMS

PHRs provide a number of potential benefits to patients, practitioners and healthcare providers. A PHR represents a single access point where all medical records of the patient are stored in one place, instead of being kept in various clinics visited by the patient. This makes it convenient for the patient as well as clinicians to access the health information, especially if there is a medical encounter overseas (Nelson, 2009). The more comprehensive health information provided by PHRs, the more it enables clinicians to make better informed decisions, reduces duplicate examinations and tests, and enables a faster, more reliable diagnosis and treatment (Tang et al., 2006). The improved documentation offered by PHRs can help to reduce or eliminate malpractice costs. Kaelber and Pan (2008) indicate that PHR systems are expensive to set up and maintain, but have the potential to significantly reduce healthcare cost in the long run.

### 2.2.2. Challenges of HRMS

Early experiences with three different PHR implementations indicated that they can be successfully deployed, but require careful attention to policies regarding privacy, security, data stewardship, and personal control (Halamka et al., 2008). The recent shut down of Google Health stresses that PHRs requires a careful design and implementation (Andrews, 2011). It was apparent that Google Health was discontinued due to the lack of consumer interest in leveraging the service: “Use of personal health records remains stagnant at 7% nationally, and few patients have even heard of the concept” (Dolan, 2011).

Interoperability is a major obstacle in the development and adoption of PHRs. A consumer controlled record will be more useful if it includes complete health data including medical records from doctors, hospitals, insurers and laboratories. However, the process of gathering health data from different sources is often complicated since responses often come on paper as photocopies or faxes, leading to inaccuracies and errors (Endsley et al.,
2.3 Web 2.0 Health Applications

2006, Wangsness, 2009). Furthermore, users are skeptical of their PHR’s content and in a previous study expressed the desire to learn more about the information sources (Peters et al., 2009). A common, preferably electronic, format is necessary, which requires partnerships and trust between healthcare providers, insurers and digital record keepers (Lohr, 2007). Privacy is a main challenge PHRs and users are generally very concerned about (Markle Foundation, 2003). Legal constraints and government policies further restrict usage and currently neither Google Health nor Microsoft HealthVault are available in New Zealand.

Usability issues are other concerns in the development and deployment of PHRs. A comparative study by UserCentric.com evaluated Google Health and Microsoft’s HealthVault on five dimensions: overall usability, utility (usefulness of features), security, privacy and trust (Peters et al., 2009). Results of the study suggested that both systems had flaws in the user experience. The survey participants stated that they only want to spend 10-30 minutes setting up a PHR, and subsequently prefer monthly, or preferably annual, updates. Hence it is important to make data entry of health information a simple, fast, and enjoyable experience. Other individual barriers that obstruct users from adapting PHRs are computer anxiety, lack of computer literacy, cognitive and physical impairments, and insufficient health literacy (Lober et al., 2006).

2.3. Web 2.0 Health Applications

The Web is becoming the ultimate resource for health information. Evidence from Elkin (2008) suggests that health consumers are increasingly depending on the Web to look for health information. The survey also indicates that most people (75% of the respondents) look for information about a specific condition, disease or symptom. People are moving beyond passive searches to interactive forums, blogs, and other social media - a trend often referred to as Web 2.0.

Web 2.0 is commonly known as “the web as a platform” (O’Reilly, 2005, Anderson, 2007) and is associated with web applications and services that facilitate interactive information sharing, rich user experience, dynamic content and user-centred design. Increasingly, more websites are built upon these ideas and are transforming the Web from a simple place to store information to a dynamic place where people regularly gather and interact. Examples of Web 2.0 include social networking sites, blogs, wikis, multimedia sharing sites, hosted services, web applications, mashups and folksonomies. The use of Web 2.0 in healthcare is evolving, as more applications and services targeting health
professionals and patients are being developed. With that trend, the term Health 2.0 is becoming popular.

There is a variety of Web 2.0 patient-focused health applications and services available to health consumers. Some examples of Web 2.0 health applications include PatientsLikeMe.com, CureTogether.com, DailyStrength.org, Disaboom.org, SugarStats.com, and DailyBurn.com. These applications provide direct patient support, promote disease awareness, and encourage positive and proactive behaviours to stay healthy. According to Sarasohn-Kahn (2008), online peer support is attractive to older adults and those living with chronic conditions, particularly if it is delivered using technology that is familiar and convenient.

2.3.1. Benefits of Web 2.0 Health Applications

The increasing number of registered members of Web 2.0 health applications indicates that patients see advantages in managing their health online - either independently, with peers or with online affinity communities and with medical professionals. According to Swan (2009), most patient-focused social health networks offer the basic level of service, emotional support and information sharing, for a variety of medical conditions. A large survey by Harris Interactive (2010) revealed that 53% of people who looked online for health information discussed what they have found with their doctors. The improved communication between patients and physicians contributes to developing trust and patient motivation.

One of the characteristics of Web 2.0 applications is the ability to leverage the collective knowledge of its users. Applications for health information interchange, such as PatientsLikeMe.com and CureTogether.com, provide illness-related information, in most cases directly from the people concerned. These applications educate patients on various diseases, symptoms and treatments via other patients that have experienced the same health condition. Conditions are often presented with easy-to-understand graphs or charts, which are based on health data aggregated from many patients. Some websites also produce good reports and summaries for patients. This increased knowledge can help patients to take a more active role in their healthcare, help medical professionals to diagnose problems earlier, and improve patient motivation and compliance. This can help patients to plan treatment more effectively with their doctors and to find solutions suiting their personal circumstances, which in turn increases compliance.

Patient-centred social networks such as DailyStrength.org and Disaboom.com, provide users with emotional support to cope with their health condition. They allow patients,
especially seniors and disabled people, to share their pain and socialise with others on the network. Most of these services allow users to communicate via mail, posting comments and chatting. For housebound patients, the network provides a social life they might otherwise not have.

Health monitoring sites such as SugarStats.com and DailyBurn.com help users to keep track of health-related parameters, visualise them, and share that data with others. They empower patients to track any progress towards their health and fitness goals. Most of the applications allow access to, and input of, health data from anywhere through mobile devices.

### 2.3.2. Challenges of Web 2.0 Health Applications

Most Web 2.0 health applications and services have an emphasis on communication, information sharing and community, rather than tackling the bigger challenges such as providing medical diagnosis or treating disease over the Web. The latter is much more difficult because it usually requires input from certified experts. However, early diagnosis and treatment of health conditions is a crucial element for senior healthcare.

Popular Web 2.0 health applications discussed above are created with a single objective in mind: either to educate patients, to provide social support or to monitor health parameters (see Figure 2.5). None of them provides all three types of functionalities. However, for a system to be truly effective and have a holistic impact on health, it needs to offer most of the important functionalities such as education, monitoring, diagnosis, rehabilitation and social support. For seniors, it is often not feasible to work with many different systems, and a single integrated user interface is necessary.

Furthermore, many of the systems have crowded user interfaces with a plethora of functionalities and are created for people who are comfortable with computers, which makes it hard for seniors to use them effectively. Special usability requirements are rarely considered. As mentioned in Chapter 1, seniors are disproportionately affected by chronic health problems, physical and mental challenges, and loneliness. Seniors could benefit tremendously from the Web 2.0 if it could be made more accessible to them.

There are several popular websites that encourage a proactive approach to prevent disease and maintain or improve health such as DailyBurn.com. However, there are various reasons why these websites are not suitable for seniors. General exercises are often too hard for seniors, and typical health conditions of seniors require special types of exercises. For instance, patients suffering from Parkinson’s disease need support for performing hand exercises to improve the mobility of their hands. Active participation such as
computer-supported exercise can be an important function of senior healthcare, which is not well supported in today’s information-centric Web 2.0.

Other disadvantages arise from the mode of communication supported by most Web 2.0 health applications. They frequently enable patients to connect with other patients, e.g. by posting comments to other patients’ health data. Pulman (2010) states that there can be a high proportion of false or misleading information provided by other patients in online self-help sites. This could be due to the absence of guidelines and lack of control to avert individuals from posting wrong or irrelevant information.

On the whole, although web-based health applications have great potential in meeting the needs and demands of health consumers, there is lack of evidence about the effectiveness, usefulness and sustainability of such tools (Yu et al., 2012).

### 2.4. Serious Games and Exertainment Applications

Research and development of digital games is putting an increasing emphasis on serious games and their benefits in therapy, interventions, healthcare programs and training (Dieterle, 2009). Exergames, or games that support physical and mental exercise, are valuable tools for fostering patient participation in health-related activities by combining entertainment and therapeutic value. Common trends have emerged in the use of games for healthcare including the increased use of games for therapy and rehabilitation, games to promote physical activity, and games that involve healthcare providers (Skiba, 2008).

Ever since the release of Nintendo Wii, videogames have become popular among the
2.4 Serious Games and Exertainment Applications

seniors (Loureiro et al., 2010). The enhanced user interaction via its low cost and revolutionary controller, Wiimote, makes it possible for them to engage in rehabilitation activities while playing games (Theng et al., 2010). Its integration with well-designed games can help users perform exercises such as limb movement while promoting motivation, active participation and social interaction (Loureiro et al., 2010). Similar to the Nintendo Wii, the Microsoft Kinect has attracted the attention of game developers and senior users, since it encourages social interaction among players. The main advantage of this controller is its hand-free interaction, which is likely to be suitable for a wide range of patients, especially seniors who often face anxiety when confronted with technology (see Figure 2.6). Such devices can aid them to interact with a health application with ease and confidence.

![Figure 2.6: Seniors playing games via an Xbox Kinect console (from Crounse, 2012).](image)

Apart from physical games, a number of brain games are designed to improve cognitive skills such as memory, planning, divided attention, and hand-eye coordination. MindHabits is a scientifically designed game with training challenges and measurement tools to help players to reduce stress by repeating positive messages and words. In one challenge, the players are required to find the smiling faces in a crowd of frowns (see Figure 2.7), which according to Dandeneau et al. (2007) can help train your mind to react to positive information. MindFit is another popular computer program for training cognitive skills, which was tested in a trial with 121 healthy seniors where half the participants used MindFit and the other half computer games. Results of the study of Butcher (2008) showed improvements for both groups on most outcome measures, but users of MindFit improved significantly more. Furthermore, Brain Training, a game designed for the Nitendo DS with the purpose of providing mental exercise, has received attention from health professionals and is claimed to be beneficial for the seniors (Nursing Home Activ-
Chapter 2 Consumer Health Informatics Applications

Ities Resource, 2011). Likewise, Lumosity is a popular online program aimed at the older demography, which targets mental processes that decline with age, including working memory, speed of processing and attention.

Figure 2.7: A game from MindHabits that requires the player to click on smiling faces (from MindHabits.com).

2.4.1. Benefits of Serious Games

Ijsselsteijn et al. (2007) suggest that “digital games may offer elderly users new and exciting ways to be entertained, stimulating mental abilities, and supporting existing and emerging social networks, both within and across generations”. Digital games can play a positive role in senior care by providing fun and mental simulation (Weisman, 1983). The sense of accomplishment and perceived self-efficacy after mastering a game can provide a significant boost to one’s self-esteem (Weisman, 1983, Ijsselsteijn et al., 2007). Wiemeyer and Kliem (2012) add that serious games provide novel prevention and rehabilitation provisions with emphasis on the following aspects: physiological, psychological, social and sensory–motor abilities. Gebel, Gurt and Wagner (as cited in Wiemeyer and Kliem, 2012) summarise that serious games without compromising their game experience have the potential to address or enhance a range of competencies which are listed in Figure 2.8.

Serious games and exertainment applications have become tools for improving fitness and changing behaviour (Dieterle, 2009). Games like “Dance Dance Revolution” have been reported to have a positive effect on the social life and physical health of players by
2.4 Serious Games and Exertainment Applications

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**Figure 2.8.** Competencies that can be enhanced by playing digital games (from Wiemeyer and Kliem, 2012).

Improving endurance, muscle strength, a sense of rhythm, and creating a setting where new friends can be found (Hoysniemi, 2006). Likewise, “Wii bowling” can encourage players to move their arms and improve their coordination (Neufeldt, 2009). Home-based stroke rehabilitation games (see Figure 2.9) are found to be beneficial to seniors affected by this illness (Burke et al., 2009).

Several studies have indicated positive outcomes among the seniors, such as increased motivation and adherence to rehabilitation, when interactive games are included in their health treatments (Betker et al., 2007, Sugarman et al., 2009). The use of modern data input peripherals in the games helps to track patient performance such as motor ability in a rehabilitation activity (Marin et al., 2011).

### 2.4.2. Challenges of Serious Games

Despite serious games having several perceived benefits, as explained in the previous section, there is some doubt about their usefulness for improving general fitness and social interactions. For example, while the Wii Fit has been endorsed by some healthcare providers such as UK’s Department of Health, investigations into its effectiveness have been mixed and several researchers report no noticeable long-term increase in exercise activity and fitness (Theng et al., 2009). One possible reason might be boredom (Owens et al., 2011).

Although there is increased awareness among developers about the needs of seniors...
in the design of health-based games, limitations of seniors are given less importance in the entire design process of current projects (Marin et al., 2011). In addition, health professionals have indicated that inappropriate games could cause seniors to perform movements that could negatively affect their physical condition (Marin et al., 2011). Wiemeyer and Kliem (2012) found that current studies on serious games are mostly centred on its short-term effects on various components such as attitude, motivation and behaviour; the long-term effects are not known.

Exercises in memory games, which train tasks such as response speed, visual search and memorisation, are likely to improve the tasks that are being practiced. However, there is a lack of evidence that this improves general cognitive abilities (Butcher, 2008).

Game playing is a common activity at senior communities, e.g. in the USA bridge and bingo are popular. Most of the time game playing is viewed primarily as a means for social interaction. Elderly participants engage in conversations and “retell and reenact their life stories” (Mangrum and Mangrum, 1995). Therefore, the game playing is more than a form of recreation, but an opportunity to teach positive self-concepts and coping with loss. So far little work has been done to incorporate these principles into computer-based games.

There is a significant need to explore and understand the needs and motivations of seniors and health conscious game users, e.g. by conducting focus group studies, interviews, surveys and general market segmentation research (Ijsselsteijn et al., 2007).
2.5. Discussion

The previous sections demonstrated that a wide variety of consumer health informatics applications are available, but that they are centred around different interest groups and follow different objectives.

Commercial telehealth applications and most health record management systems are centred around the clinical users, the health service provider and the vendor’s interest of generating a reoccurring revenue stream. In general, the applications provide a good job of collecting, analysing and monitoring health data, but offer little support for users to commence positive lifestyle changes. In most cases, the applications are obtrusive, i.e. they do not fit into the regular activities of the user, hence being perceived as disruptive. For example, as mentioned, in one study PHRs users expressed the wish to update data at most monthly or preferably yearly (Peters et al., 2009). A few vendors offer kiosk-style applications which enable, for example, all family members participating in health monitoring and as such can increase patient motivation and compliance.

Health information websites offer an impressive range of information, but it can be difficult for the user to assess the reliability, meaning, and implications of the information. Web-based discussion and support groups can provide a more personal experience and add a social factor which can help patients with coping and commencing positive lifestyle changes. Serious games and exertainment applications are arguably the most patient centered consumer health informatics applications. Since they are usually purchased by the patient, the vendor is motivated to make them as attractive as possible for the user. However, as discussed previously, research reports mixed results about their effectiveness. One hypothesis is that the content of such applications can become repetitive and boring and hence lifestyle changes are only temporary (Owens et al., 2011). In most cases, content is controlled by the vendor and in order to do a new type of exercise, users would have to purchase a new game and possibly new equipment. An improvement is the iTunes concept, which enables user to easily download new iPhone games. There is a similar concept for Android applications. However, most of the applications must be purchased and costs can add up quickly and monitoring data is not shared between different health applications (e.g. pedometer, sleep pattern monitor, brain exerciser). In other words, a continuous recording of health parameters and activities is not possible.

In summary, existing consumer health informatics applications are often obtrusive and require patients to do tasks, which can be perceived as disruptive, repetitive and boring. Telehealth systems and console-based exercise games are expensive and have limited con-
tent leading to user resistance after long term usage. Few applications address social and psychological aspects, and more support is needed for sharing monitoring and activity data.

There are also some more fundamental design issues. For instance, most telehealth applications are designed for monitoring and treating patients with chronic diseases, but do little to prevent them (Dishman, 2004). Furthermore, the high cost of these systems justifies their employment only for already seriously sick patients who otherwise would need expensive hospital or nursing care. In order to tackle the coming healthcare crisis, telehealth systems must be developed which prevent diseases by encouraging positive lifestyle changes and recording fitness and vital signs. More emphasis must be put on prevention, early diagnosis, rehabilitation and self-management in order to reduce healthcare costs.

Motivation and compliance must be increased by making systems user-friendly, convenient, fun, and as unobtrusive as possible. Feedback from the research reviewed in the previous section suggests that this can be achieved by integrating health related tasks into everyday activities, by giving users a more active role in monitoring and improving their health, and by adding a social dimension. Note that nobody can force, say, an overweight person to diet or a smoker to quit smoking. Such decisions must be done by the user, but can be encouraged by education, a positive self-image, and social support.

2.6. Conclusion

In this chapter, we reviewed, evaluated and categorised a wide range of consumer health informatics applications from the user perspective. While some of these tools have been clinically tested to confirm their efficacy, a common problem is that their design reflects market requirements. Benefits and shortcomings of each category of applications were identified and clinical and scientific evidence was given where available. Based on this research, we identified principal barriers preventing a wider and more effective usage of these technologies in healthcare applications.

The Web is the most important platform of our time and quickly evolving, for various reasons. Apart from reaching a wider audience, the principle advantage of leveraging a web-based system is the integration of third party applications, i.e. possibility of developing an evolving system. Serious games are often patient-centric, but could bore the user in the long run – positive lifestyle changes are temporary. They are also controlled by the vendor and will require additional cost to add any functionality. The identified short-
2.6 Conclusion

Comings of current consumer health informatics applications motivate the development of a novel web-based telehealth system, HC4L, which is ubiquitous, extendable by third parties, contains social aspects, encourages cognitive engagement, and puts the user in control.

Prior to development of HC4L, it was necessary to obtain a good understanding of the common issues faced by seniors with current home telehealth systems. In the next chapter, we categorise the common barriers and present solutions to overcome such problems, which enables us to formulate general requirements for a patient-centric telehealth system.
3. Seniors and Telehealth

In the previous chapter, we analysed and evaluated popular consumer health informatics applications and explicitly identified the need to develop a novel web-based telehealth system. In this chapter, we present a taxonomy of requirements and design concepts for home telehealth systems which enable a more patient-centric design. We explore the usability problems of past and current telehealth systems, i.e. PC-based telehealth platforms and telehealth monitoring devices. Problems faced by users of home telehealth systems are identified and solutions delineated. The aim is to build a solid foundation of the technology needs of the senior population to aid development of novel and more general telehealth solutions which are effective and more widely available.

Section 3.1 describes the taxonomy used to classify common problems experienced by the seniors in using home telehealth systems. Section 3.2, Section 3.3 and Section 3.4 cover the three classes of barriers: individual limitations, system limitations and environmental variables, respectively. These sections provide discussion of corresponding problems with possible suggestions, which can be considered in the design of future home-based telehealth solutions. Parts of this chapter have been published in Singh et al. (2010b) and Singh et al. (2010c).

3.1. A Taxonomy of Requirements

Telehealth solutions are increasingly being developed to improve healthcare and overcome its mounting costs. Many telehealth systems are designed according to the Principles of Universal Design. Universal design, also known as design for all, is defined by Story et al. (1998) as “the design of products and environments to be usable to the greatest extent possible by people of all ages and abilities”. There are other general guidelines to implement telehealth systems such as the User Experience Design Guidelines for Telecare Services by Von Niman et al. (2006, 2007). The requirements presented in this chapter take a holistic approach in understanding the usability issues and current expectations of users towards telehealth systems.
The design shortcomings of current telehealth systems are best illustrated by commercial systems. Most systems target the clinical users and provide detailed feedback to medical staff, but limited feedback to users. In most cases, only monitoring parameters are displayed and just a few solutions provide graphical output of historic monitoring parameters. Additional patient feedback usually only occurs during the scheduled meetings or if a health parameter is outside the permissible range, which is displayed as “warning” in the clinical interface. Involvement of family and social contacts is limited and usually only possible for people which are physically present, although some systems allow family members to get restricted access to the clinical interface. Active patient participation is usually limited to activating a monitoring session. We are not aware of any system which enables patients to take actively charge of their health by enabling them to create diet, exercise and fitness plans, monitor goals, and obtain guidance and information (e.g. in the form of videos).

Figure 3.1.: The three classes of common problems faced by older adults in using telehealth systems.

It is a challenge to discuss telehealth as a generic class, especially for the purposes of usability, since there is such diversity of platforms, devices and diseases. However, it is important to discuss usability issues of current telehealth systems broadly, as it is our aim to propose a generic telehealth system that is ubiquitous and not confined to particular diseases. Therefore, we have classified the common barriers that obstruct older patients’ abilities to use healthcare systems into three broad categories: individual limita-
3.2 Addressing Individual Limitations

Individual limitations in this context refer to any health related problems or other self-inabilities that obstruct users from using the health application effectively. Figure 3.2 depicts features that are perceived as important to overcome this barrier, and which are explained in the subsequent sections.

3.2.1. Functionality

An important factor impacting the effectiveness and subsequently the usability of telehealth systems is its functionality, i.e. its functions and capabilities. Some important features are natural input, multi-language support, useful reminders, and a design reducing computer anxiety, which can be customised to users’ self-efficacy.

Telehealth systems should be designed to enable users to interact with the system naturally. For example, seniors with tremors or Parkinson’s disease experience difficulties in moving the mouse (Rahimpour et al., 2008). Kaufman et al. (2003) conducted a usability study to assess computer-based healthcare technologies and claim that using the keyboard and mouse is a formidable obstacle to some users, as these users were not able to complete all the planned tasks. One possible solution is to provide touch screen input as is the
Language should not be a barrier for users to use telehealth systems (Rahimpour et al., 2008). Most of the existing telehealth systems we are aware of were initially developed in English and are centred around the Western society. In order to be universally usable, multilanguage support is an important issue. It is interesting to note that Tunstall’s telehealth monitors (Tunstall.co.uk) support a wide range of different languages and local dialects where needed.

Reminders are a useful feature of telehealth systems. Seniors generally face difficulties in remembering tasks such as taking their medication (Mynatt et al., 2000). Current telecare systems usually provide reminders for monitoring sessions and often can be configured to provide medication reminders. A more comprehensive scheduling system could also be envisioned, e.g. to provide reminders to attend a doctor’s appointment.

Some older adults have fear and avoid being confronted with modern technology such as computer-based health application system. Some of the participants of a study of Rahimpour et al. (2008) on computer-based telehealth systems expressed that it would be too difficult for seniors to learn how to use the system. Although the patients were informed that they did not need any computer knowledge to use the system and the system was not personal computer-based, some patients perceived the system as a computer and expressed their computer anxiety. Rahimpour et al. (2008) report that one participant expressed: “I don’t know anything about computers... I like the system, but first of all, it

Figure 3.2.: Suggestions to overcome individual limitations.

Language should not be a barrier for users to use telehealth systems (AmericanTelecare.com).

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Figure 3.2.: Suggestions to overcome individual limitations.
is very hard to use it. I don’t know how to use computers. I don’t know what will happen to the computer if I press the wrong button.” Many existing telecare systems address this problem by using interfaces which consists of only a screen and a few buttons and therefore are more comparable to a large digital clock than a computer, as illustrated in Figure 3.3.

![MyMedic Telehealth Monitor (from Tunstall.com)](image)

Users have different self-efficacies or abilities to use computer systems efficiently. Some users may be slow while others are fast. A common recommendation is to customise the system according to the individuals’ levels of the system self-efficacy and anxiety (Rahimpour et al., 2008). We could meet this requirement by creating a more personalised system by allowing the users to make adjustments to suite their limitations or preference. For instance, there could be more detailed instructions on each stage of the system to cater for users without computer experience. This group of users may need further explanation on terms like “double-click” or “pointer” than users with computer experience. Another example of a useful customisation is to allow users to turn off the reminder feature if they do not need reminders to take their medication or if they find this feature distracting. A personalised system will indirectly train users to increase their self-efficacy and reduce their anxiety in using the system.

### 3.2.2. Understandability

One core requirement of telehealth systems is that they are easy to understand. Systems with many features often appear complicated, especially for senior users suffering from computer anxiety. Careful guidance is needed to ensure users know how to use the sys-
tem and how to make effective use of it. Design recommendations are to use a mental model illustrating how the system works and sufficient instructions for its use, e.g. using integrated videos and online help.

According to Kaufman et al. (2003), the users need to understand how the system works at the outset. This will aid users, especially seniors, in getting a rough idea about what is expected from them when using the system. We could guide the users by having a short video describing how the system works. Otherwise, we could have a separate screen that clearly illustrates and explains how the system works. This piece of information should be part of the system and not a separate user manual sheet. The mental model is aimed at providing an overview of how the system works and not to give detailed instructions to use the system.

Telehealth systems should provide sufficient instructions to enable comfortable use. If designed properly then even senior patients with limited computer experience can use such a system successfully (Evangelista et al., 2006). Rahimpour et al. (2008) indicate that audio instructions on each stage of the application are a helpful feature, which is essential for visually impaired patients. Note that visual impairment is a common side effect of several chronic diseases such as diabetes and occurrences increase with age.

### 3.2.3. Interface Design

The user interface of telehealth systems should be designed with individual limitations of the user, especially senior users, in mind. The interface should cater for the unique mental, physical and psychological challenges of the patients. It should support readability, contain more graphics than texts, use colours appropriately, and have clear transitions between different sections of the system.

Kaufman et al. (2003) suggest that older adults are more affected or confused by distracting context such as clutter on a screen. This may limit their ability to selectively attend to relevant screen features and perform concurrent tasks. For example, a cluttered screen will disallow them to work on the computer and hold a conversation with their doctors at the same time. Small font size and links that are inadequately spaced are some known concerns. There should be more white space on the screen to allow users to see important information clearly. If users do not know how to use the system, they should be able to determine how to use it by making educated guesses. Even when the guesses are wrong, the system should provide reasonable results from which users can readily understand and ideally learn. Apart from that, the system interface should be designed with high contrasting colours to differentiate the fonts and background and the font size
should be big enough to accommodate users with vision problems (Nahm et al., 2004).

Important information should be presented with more pictures than words. We should avoid using text alone on buttons. Icons with both graphics and text will aid users in quickly understanding what they need to do next. Ojel-Jaramillo and Cañas (2006) tested and confirmed that seniors make fewer errors in using home telehealth care devices when they deal with icons instead of words in the device interface. Hence, telehealth system interfaces should be designed more graphical than textual. People understand the meaning of pictures (visual) better than words ( textual) and there is more access to meaning when both types of cognitive representations (visual and textual) of the icons are provided (see Figure 3.4).

![Figure 3.4: Examples of icons to represent functions of a telecare system interface (from Ojel-Jaramillo and Cañas, 2006).]

We should be cautious in the selection of colours for the interface design. The colours used should not distract users’ interaction with the system. Users, especially many seniors, have poor colour and contrast sensitivity. Colour blindness is common especially among males. Hence, users might not be able to differentiate between colours, particularly when they are presented with only dark or bright colours. According to Arditi (2012), designers should lighten the light colours and darken the dark colours to increase its visual accessibility.

Kaufman et al. (2003) add that there should be clear transition between screens or sections of the applications. This will help users to keep track of the flow of the system which otherwise will make them feel confused about where they are in the system.

### 3.2.4. Operational Support Services

The telehealth system providers need to ensure that there is sufficient operational support available to the users. A special training program should be designed for the older users of the system. Upon installation of the system, there should be on-going technical support and maintenance services provided to the users.
Most of the home telehealth applications incorporate training programs for its users. Rahimpour et al. (2008) imply that older adults may take more time in absorbing the training lesson or learning how to use the system. A common recommendation is to conduct a separate training session specifically designed for the older adults. Tailored training components should aim to reduce users’ anxiety and improve users’ self-efficacy in using the system.

The system developers should ensure that there is sufficient technical support available to the users. Senior patients do not want to be involved with technical facets of the system. Agrell et al. (2000) conducted a study on patients’ perceptions regarding home telecare. One of the participants of the study expressed: “Development (in the) technology should make it unnecessary for the patient to get involved in technical details ... you should be allowed to just be sick”. Therefore, the technical support staff need to make home visits to solve the technical problems instead of providing detailed step-by-step instructions to the users over the phone or online. The technical support team should also be responsible for the maintenance of the system (Rahimpour et al., 2008).

### 3.3. Addressing System Limitations

System limitations are characteristics of the technology (telehealth product or system) that prevent the user from making effective use of a system. Figure 3.5 summarises some of the main recommendations to overcome this problem.

![Figure 3.5: Suggestions to overcome system limitations.](image-url)
3.3 Addressing System Limitations

3.3.1. Reduced Complexity

Telehealth systems enable patients to receive healthcare treatments while they remain at their own homes. However, this benefit places high responsibility on the patients in managing his or her own health. Therefore, it is essential to make things easy for the users. Since telehealth systems mostly collect health data from the patients, our recommendation is to ease the process of data entry into the system. Most commercial systems we reviewed have interfaces carefully designed in this aspect. For example, vital signs measurements are often uploaded automatically using Bluetooth connectivity, and questions regarding emotional health and general well-being are usually presented as multi-choice questionnaires and can be answered by pressing a single button. All other tasks required to be carried out by the patients should also be simplified.

Telehealth systems are generally designed to collect health information from the patients. Patients’ weight is a common health parameter monitored to prevent and/or detect numerous health issues. Some weighing scales use Bluetooth technology to automatically transfer the weight measurements to the patient station. It is easier to enter the weight data using this method, but the technology is quite expensive. A cheaper solution would be to use a common weighing scale and expect the user to enter the weight measure manually into the system. Simple plausibility tests must be conducted to identify common input errors, e.g. pressing the same key twice (779) or pressing a neighbouring key (69 instead of 79).

Users need to feel motivated to use the system. Tedious tasks can cause fatigue and boredom to users (Kaufman et al., 2003). Therefore, every task required to be performed by the user should be simplified. For example, it should be easy for the users to create their health profiles with just a few button clicks and as few instructions as possible.

3.3.2. Feedback

Apart from providing feedback to the clinicians, telehealth systems should be designed to provide necessary feedback to the patients. Most importantly, the patients deserve to know how their health is progressing. Graphical representations of health parameters and monitoring data can help patients to visualise their current health state and may even motivate them in looking after their health (Fischer et al., 2011, Lee et al., 2011b).

The system should provide necessary feedback for every action taken by the user. Most of the current telehealth systems provide detailed health information to the doctors, but little feedback is given to the patients. Patients are mainly concerned about their health
status when using telehealth systems (Rahimpour et al., 2008). Hence, upon obtaining the necessary information from a user, the system should show the health status of the user at an appropriate level (amount of details and medical terminology). For instance, upon entering the necessary clinical measurements, the system should inform the user whether the measurements are within the normal range or not.

A day-to-day graphical representation of users’ health data will enable both the clinician and the patient to visualise the health progress better. This could be a powerful tool for communication between the patient and the clinician. It also gives the patient a sense of empowerment which can motivate them to maintain and improve their health. Carefusion’s TeleAM system provides graphical representation for health parameter such as blood glucose, blood pressure, and peak flow (see Figure 3.6).

![Graphical representation of health parameters](Carefusion.com)

**Figure 3.6.** TeleAM’s graphical representation of patients’ health parameters (from Carefusion.com).

### 3.3.3. Non-functional Requirements

Non-functional requirements specify criteria that can be used to judge the operation of a system, rather than specific behaviours. So, besides being able to measure health parameters of the patients, it is necessary that the telehealth system provides reliable mea-
3.4 Addressing Environmental Variables

Measurement of health parameters. Likewise, besides being able to capture health records of patients, the system must be secure and ensure patient privacy and confidentiality.

The system must be stable, interoperate without interruption and provide reliable monitored values (Botsis et al., 2008). Several participants of a home telecare system study were interested in knowing to what extent the system is reliable in terms of obtaining accurate measures (such as blood pressure) and what processes had been implemented to recognise wrong measurements (Rahimpour et al., 2008). So, if the system enables users to measure and record their blood pressure, the system should capture the accurate count.

Telehealth systems should support computer security and data confidentiality (Botsis et al., 2008). The majority of participants of a computer-based telehealth study agreed that they were not concerned about confidentiality related to the system provided that access to the health information would be limited to relevant medical doctors (Rahimpour et al., 2008). Agrell et al. (2000) report that users talked less about personal issues when using telehealth equipment, than when talking to a nurse. These participants were under the impression that tele-encounters pose similar confidentiality breaches associated with computer-based Internet or electronic mail communications. Therefore, the application should address this requirement and provide suitable information to gain trust from users.

3.4. Addressing Environmental Variables

Environmental variables are other external challenges that prohibit users from using the system as expected. Figure 3.7 summarises some points to address this problem.

Figure 3.7: Suggestions addressing environmental variables.
3.4.1. Active User Participation

There is wide agreement that engaging patients to be an active part of the care process is an essential element of the quality of care (Hibbard and Cunningham, 2008). Active user participation means that the users are in control of their own health. Most current telehealth solutions are designed for the clinicians to look after their patients’ health conditions. The systems mostly collect clinical data such as blood pressure count, pulse rate and weight from the patients for the clinician to diagnose and suggest treatments. The patients have a passive role, as providers of their health data, instead of actively participating in managing their own health.

Motivation is an important factor to enable patients to take charge of their healthcare. We could possibly motivate the change of behaviour in patients by increasing awareness about their condition, i.e. letting them know about their current health status. This could increase their motivation by enabling them to realise the reason for change. Other ways patients can be encouraged to play an active role in their healthcare is by enabling them to ask questions, choose between multiple options, and set goals and take actions to improve their health. An example is diet and exercise plans users create according to their own preferences in cooperation with medical experts (Shannon, 2009).

3.4.2. Multi-User Support

Many telecare systems are designed for use by one patient only. This increases security and simplifies data input, e.g. if a patient stands on a scale with Bluetooth connectivity the system automatically assumes that the measurement is by the user. However, the disadvantages of a single user set-up outweigh the positive aspects, as costs are multiplied if several household members require telecare. Furthermore, even if only one user requires usage of the system, patient motivation can be increased if several household members participate, since this adds a social dimension to the system. Furthermore, a single user system has to be transported when travelling - this is a particular disadvantage to many Māori and Pacific Island communities which frequently meet at Marae and other meeting centres. A multi-user system can be installed at community meeting places which not only increases accessibility, but also further increases motivation and social support. We therefore strongly recommend multi-user support (Rahimpour et al., 2008), e.g. by having individual user logins or swipe card access.
3.4.3. Face-to-face Communication

Home telehealth applications are being developed to reduce the number of home visits and specialist visits by practitioners and patients, respectively. However, there is a strong concern regarding lacking face-to-face communication between the doctor and the patient (Agrell et al., 2000). Older adults still want to see and communicate with their health providers. This requirement can be accommodated by incorporating video consultations. Although most of the participants of a study conducted by Agrell et al. (2000) have perceived major differences between “virtual” and in person home nursing visits, they have placed a high value on the video presence of the nurse in home telecare. For example, the Intel’s Health Guide PHS6000 includes an integrated camera, allowing patients to conduct video calls with their healthcare professionals.

3.4.4. Social Support

Some users expect telehealth systems to provide some form of social support besides the home-based healthcare. Rahimpour et al. (2008) quote one study participant as expressing: “... I live on my own with no one around me, not a neighbour, a dog ... not even a cat. I like it (system) because I am on my own. Health wise I feel like I am not on my own with this system”. Older people may receive less human contact when monitoring technology replaces nurse visits (Baharin et al., 2009). According to (Hirsch et al., 2000), seniors’ quality of life is dependent on a rich set of social relationships among a variety of individuals. Therefore, existing telecare architectures should be extended to provide awareness and connectedness between older people, their informal carers and family members (Baharin et al., 2009).

Recently, Emota (Emota.net) developed an emotional networking platform, which uses touch screen Internet tablets and picture frames in a cartoon-like format, to help seniors maintain closeness and mutual awareness with their loved ones. Similarly, Go-myLife (gomylife-project.eu), a mobile social networking solution aimed at integrating existing mainstream online social networks to meet the needs of seniors, is underway. Farkas (2010) reports a list of senior-oriented social networks with their respective objectives and features. These tools are generally aimed at tackling isolation, which is a huge issue for seniors who live alone. However, we believe that social support should be provided as part of telehealth applications used by seniors, in order to avoid having to switch between different platforms to manage healthcare.
3.5. Conclusion

The growing deployment of telehealth interventions helps us to understand general requirements of health consumers towards these systems. Usability issues of current telehealth systems have mostly been motivated by medically quantifiable patient parameters, such as vision and motor control. In this chapter, we described a taxonomy of requirements for telehealth systems, which takes a holistic view incorporating psychological and environmental barriers. It allows us to understand current expectations of users towards telehealth systems. Problems faced by seniors were categorised as individual limitations, system limitations and environmental variables, and solutions to problems emerging from each category were suggested.

We have obtained a good understanding of the user needs and design concepts which enables a more patient-centric design. However, we have not discussed the specific requirements of HC4L. In the next chapter, we will present a study conducted via systematic interviews with a group of seniors to formulate the user interface and functional requirements of the system.
4. Requirements Analysis

From Chapter 1, it is clear that we are interested to leverage the Web as a medium to deliver healthcare services to seniors. A web-based solution can reach a wider audience at a low cost, including seniors (i.e. following from the continued growth in the number of seniors going online), and most importantly, enable us to stimulate integration of third party applications.

In the previous chapter, we described general requirements for home telehealth systems which enable a more patient-centric design. This chapter presents specific requirements of a web-based telehealth system, findings of an investigation designed to identify the needs of seniors with regard to the interface and functional requirements.

Section 4.1 lists the goals of the study. Methodology used in conducting the study is described in Section 4.2. Results of the study are presented in Section 4.3 and discussed in Section 4.4. Parts of this chapter were published in Dhillon et al. (2011c).

4.1. Aims of the Study

Several studies have been conducted in the past to identify better ways to design web interfaces for the seniors (Demiris et al., 2001, Anson, 2006), and organisations have published guidelines for designing web pages for seniors (Hodes and Lindberg, 2002, Chisnell and Redish, 2005). However, most of the studies focus on user interface requirements in general, and do not discuss the specific requirements of web-based telehealth applications.

The main aim of this study is to identify the user requirements of HC4L from potential users via systematic interviews. The interviews had the following two objectives: (1) to determine the most important functional requirements; and (2) to find an optimal user interface.

We also evaluate our initial design ideas by using a paper prototype of the system. The paper-based prototype was inspired by user feedback (obtained from the first four participants of the study) and an analysis of existing interfaces of similar applications.
shown to the participants. Selected screenshots of the paper prototype can be found in Appendix B on page 159.

4.2. Methodology

The study was designed as a qualitative inquiry focusing on seniors’ perceptions and requirements towards web-based health systems. Participants were recruited by posting advertisements in senior community centres, clubs and retirement homes. Participants had to be aged 60 and should be New Zealand citizens. Semi-structured interviews were conducted with each participant individually in respondents’ homes between March and April 2011. Each interview lasted 45 to 60 minutes and participants were free to develop the conversation within each topic area. All interviews were tape recorded and anonymised. Notes were taken when the participant was elaborating the answer for each question. Impressions and gestures were carefully noted.

This semi-structured interview method was preferable over other interview methods because of its flexibility, i.e. allowing us to bring up new questions during the interview as a result of what the interviewee said. At the same time, the interviewee was free to share anything related to the conversation. Prior to the interviews, we prepared a framework of themes to be explored, including computer experience and usage, managing healthcare, and loneliness and social networks. These themes were used to categorise information gathered from the participants and most importantly to comprehend the requirements for a web-based patient-centric telehealth system by obtaining an insight into seniors’ lifestyles. The idea was to grasp seniors’ expectations towards current web technologies to support their healthcare and to formulate the functional requirements of our system. The interview questions included: “How often do you visit the doctor?” “How often do you use the computer and what do you use it for?” “What is your opinion about using the Internet to sustain and manage health from home?” “How are you managing or maintaining your health condition?” “Do you ever feel lonely?” “How do you socialise or keep in touch with your family and friends?” The interview protocol is included Appendix C.2 on page 165.

The interviews were made in an environment which was familiar to the participants, and after each interview there was time for reflection. All the questions were asked verbally, with the exception of the oldest participant (age 87) who had a hearing impairment. For him, the questions were written down on paper.

For the second part of the interview, the paper prototype of HC4L and three screen-
4.2 Methodology

shots of current Web 2.0 health applications were shown to the participants (see Section 4.3 on page 17 for an overview about Web 2.0 health applications). Paper-based prototypes are known to be as equally effective as computer-based prototypes (Walker et al., 2002), therefore a paper prototype of HC4L was employed to assess the preliminary design concept of the system. First, an overview of how the system will work was provided. Subsequently, participants indicated where they want to click to use the system and the page was changed to show that screen. Upon obtaining feedback on the paper prototype, the screenshots of the three health applications were described briefly. Selected webpages of these applications were printed in colour on A3 size paper. The purpose of the screenshots was to identify aspects users like and dislike about the interfaces, which helps towards creating an optimal user interface for our system. The following applications were selected because they address the general health of users and represent three different interface styles: MyFitnessPal.com, DailyBurn.com and DailyStrength.org. During this session, the questions included: “What do you think of these system interfaces?” “What do you like and dislike about these pages?” “Is there any useful functions you would like to see in the new system?” “What do you think could have been better?”

4.2.1. Participants

The sample involved was based on volunteers but we had a good balance of gender, living style and ethnicity. Eight seniors (four males and four females) with basic computer experience were interviewed. The participants’ mean age was 72 (range 60 to 87, SD (Standard Deviation) = 10.23) years. Five participants were living in their own homes with families, and three were living in a retirement home. Four participants were Indian, three were European and one was Asian. Individual profiles of the participants are available at Appendix C.1 on page 165.

4.2.2. Data Analysis

The interviews were analysed using qualitative content analysis (Graneheim and Lundman, 2004). The interview transcript was read and the recording was listed first to acquire a first impression of the content. Thereafter, all the text was used in the analysis and divided into meaning-units corresponding to the specific themes. The number of statements regarding particular issues was counted, and comments with the highest frequency were identified as important. Illustrative quotes were also highlighted.
4.3. Results

4.3.1. Computer Experience and Usage

Six out of eight participants reported using a computer almost daily. The oldest participant (IP5) commented that he used to be an active user but does not use the computer anymore as he wants to live a quiet life. Most of the participants used a computer for email and Skype to keep in touch with their family and friends living overseas. One participant (IP2) did not have an email account because she disliked typing (“The computer is like my play partner. I use the computer to enjoy myself but I do not like typing”). To use Skype or any application which requires a username and password, she asked for help from her family members to log her on. The majority of the participants faced problems in remembering their passwords, and they got annoyed with pop-ups. Other problems included websites with cluttered interfaces or small fonts, which caused respondents to close them immediately.

4.3.2. Managing Healthcare

Six out of eight participants reported using the Web to search for information related to their health. However, none trusted the information they found on the Web completely, and hence discussed the findings with their doctor. Most of the time, the information found is regarded as marginal, unless the source is reliable, such as an article provided by health professionals. The participants often searched for more information about any new prescription made by their physician (e.g. in order to learn about side effects).

No participant reported using a Web 2.0 health application, and only one played computer games. Four participants had heard about exercise games such as Wii Fit, but nobody used them.

All participants monitored their health by visiting their physician, with half of respondents doing visits at least every three months, and the rest only when feeling unwell or prompted by their doctor. One participant visited the physiotherapist every week due to a recent leg injury. Six out of eight participants cannot drive anymore and are depending on someone (a family member or the retirement home’s driver) to take them to see the doctor.

None of the participants was using telehealth applications to monitor their health. All of them depend on their physician to monitor their vital signs. The majority of them (five participants) did regular walking to maintain their health. A few of them commented that
4.3 Results

they like to walk every day, but at times they are unable to do so due to weather conditions. Other ways participants manage their health included: maintaining healthy food habits, being vegetarian, having a positive mindset, practising Yoga or Tai Chi, playing indoor bowling, and going shopping.

Six participants agreed that family support is crucial for managing health. One participant (IP3) commented that: “Without help from family, we can’t sustain”.

4.3.3. Loneliness and Social Networks

Only two out of eight participants shared that they feel lonely at times. One of the participants (IP5) who live by himself in the retirement home expressed: “My wife died four years back. I miss my wife very much so I feel lonely at times ever since then.”

The computer was an important tool for socialising and staying in touch with friends. Skype was most popular (six participants), with email coming second. One participant (IP7) added that: “It is convenient to socialise by using the computer because we can’t drive.” Other ways to maintain social contact included home visits, phone calls, and playing indoor bowling with other seniors.

Five out of eight participants did not have a Facebook account. Most of them felt that Facebook was made for younger people and does not have sufficient users in their age group. Other reasons for avoiding Facebook included privacy (i.e. sharing personal information with others), lack of user friendliness, and taking up too much time.

Out of the three participants using Facebook, one (IP3) reported that her children created the page for her, and that she mostly visits Facebook when she receives an email stating someone has commented on her page. The other two participants (who were husband and wife, i.e. IP7 and IP8) explained that they have a shared account. They visit Facebook almost daily. They both like Facebook because of its “simplicity”. One of them added that: “Even if a friend hasn’t been in touch with us for a week, we can still see their activities and they can see ours.”

4.3.4. Interfaces Requirements

Among the three web interfaces tested in the user study, DailyBurn.com (see Figure 4.1 on the following page) was liked most by the participants. Almost all of them (seven out of eight) liked the colourful icons on the left. DailyBurn uses a good contrast of colours for most of the items presented on the interface. The colours attracted the study participants’ attention immediately. One participant (IP6) expressed that the colours are
inviting (“Come read me”). Almost all of them preferred the use of icons combined with text rather than just text. Five participants got excited looking at the weight chart presented on the interface, and none of them were aware of such an application already being available online. Only one participant felt the interface was presented with too many colours.

Figure 4.1: Screenshot of the homepage of DailyBurn.com demonstrating their colour, icon choice and user interface layout.

MyFitnessPal.com (see Figure 4.2 on the next page) had the second most popular interface. The study participants liked the “clear” layout. Three respondents liked the idea of having the “Whats on your mind?” text box, just like Facebook. One participant (IP4) expressed that this is a good feature because it enables users to share (“It is good to share, why do you want to keep it to your own self, let it go to others, they might benefit on something you say”). However, the interface uses less colours, i.e. mostly different tones of blue. Some of the respondents felt that the items on the screen should be more distinguishable. For example, one respondent (IP1) expressed: “Use a different colour for different purpose.” He also commented that: “It takes a bit time to identify which button is for what purpose”. The page title, “News Feed - All Updates”, could be misleading to seniors. The oldest participant of the study (IP5) thought it was containing some important news, i.e. like news on the television.
4.3 Results

Figure 4.2.: Screenshot of the homepage of MyFitnessPal.com demonstrating their colour, icon choice and user interface layout.

DailyStrength.org (see Figure 4.3 on the following page) was the least popular interface in the study. The majority (six respondents) felt it was too crowded, i.e. it contained too much information. One participant (IP6) said: “It’s tiring” and another participant (IP2) suggested that: “The information should be straight to the point, e.g. my calories is this, my weight is this.” Several participants suggested that there were too many links on the left and the font size was too small. One of the participants liked the idea of having a chat box.

The majority of participants preferred a menu bar at the top, rather than the left side, and light blue or green backgrounds. One of the participants (IP2) expressed that: “Green is appealing for the eyes especially if we use it for long time.” Another respondent (IP6) expressed that: “Green is a suitable colour for health systems, as it means hope and life”.

All participants generally liked the use of icons in the paper-based prototype of HC4L, but two participants found that not all the icons were suitable. One participant (IP1) found that the plus sign in the icon for an “add applications” function (see Figure B.1 on page 160) looks like an icon for medicine or a red cross. Another participant (IP5) thought the cartoon-like icon for the user profile page would be related to children. This indicates that seniors may have different associations for some of the icons that have
become commonplace on the Web. Some participants were very concerned about privacy. One user (IP1) suggested clearly mentioning on the user profile page that all information entered there is strictly confidential. He mentioned that most people do not have the time to read the lengthy terms and conditions to find out about privacy. He suggested a lock icon to express that all data entered on a page are treated as confidential.

In HC4L, users are expected to rate an application or write a review after using it (see Figure B.2 on page 161). Most of the participants liked this idea, but one of the participants (IP1) suggested that the rating should be made optional by clearly stating on the screen that it is not compulsory to rate the application. The participant felt that only health professionals (such as doctors) are able to rate health applications.

4.3.5. Functional Requirements

Almost all of the respondents expressed that the system should be user-friendly. The user should only be required to deal with one thing at a time. One participant (IP2) commented that she will need assistance to use the system for the first time.

Half of the participants expressed the desire to make video calls to doctors from their homes, especially because they are not able to drive anymore. However, one of them (IP3)
was concerned about the cost of such a feature and some indicated that they prefer to see the doctor personally, since they want to monitor their health status (i.e. pulse rate, blood pressure, etc.).

Some of the respondents requested a reminder feature for doctor’s appointments and taking medication. The reminder should be synchronised with their mobile phones since they will not use their computer regularly.

Many respondents suggested that it would be very useful to have their health records transferred from their medical centre to the system. They want their health records to be accessible to them especially when they go overseas to meet their family members and friends. Note, however, that such a feature might conflict with regulatory requirements.

Several users suggested adding an application for diet management. One of the participants (IP3) suggested: “The system should inform what your diet should be and how much you should eat for a particular health problem.” Another participant (IP6) recommended that the system should suggest health activities for specific health condition, illness or state of health. The participant added that we need to be careful with the choice of words used in the system. (“The system should not use the term “illness”, because people do not like to be called ill.”)

One senior (IP3) inquired whether the system will enable her to compare her health with her friends. She added that: “It will motivate if we can see if we are doing better than our peers.” Others suggested features where applications track health (e.g. weight, glucose and cholesterol), physiotherapy exercise for body pains (e.g. shoulder, back) and games (e.g. Mahjong, Scrabble).

### 4.4. Discussion

Results from the interview show that most seniors are using the computer to communicate with their friends or to search for information related to their health, but none of the interviewed participants used web-based systems for monitoring or managing their health. Most users are not aware of existing Web 2.0 health applications and problems exist with interfaces and combining different types of functionalities. A web-based telehealth system should offer and integrate a large number of functionalities and present them with a simple, unified, user-friendly interface. The key requirement for the expected user interface is simplicity, which according to Preece et al. (2002) is a crucial interaction design principle that can be achieved by discarding unnecessary text and design elements (e.g. icons, buttons, links).
Most of the participants prefer visualisation of health parameters using graphs, which helps them to understand problems and track changes in their health status. They feel that it gives them satisfaction if, for example, the graph shows their weight has reduced, but will make them feel bad if their weight has increased. Care has to be taken to manage patient expectations, and provide encouragement and explanations.

Since most seniors agree that family support is crucial for managing their health, we strive to include members of users’ families, social circles and support groups. For instance, an email alert about the activities done by the senior can be sent to a family member or support person (nurse), who can encourage the user to do necessary tasks such as exercises or vital sign monitoring, and find out the reasons for not doing them.

The majority of the participants like the idea of managing their health using the computer, e.g., doing exercises via the computer to improve or maintain their health. By having such an application, users will be encouraged to perform exercises regardless of the weather conditions. However, one participant (IP1) pointed out that there should be confirmation from a health professional that a particular exercise in the system is suitable for a particular disease. Half of the respondents felt that it is important to keep track of all the activities they do to manage their health. One of the participants (IP3) added that: “It will be very useful to have a record of what we have done and tell me what more I have to do. We can share that information with doctors as normally we just mention we are doing exercises but we can’t tell exactly how much we did.” Although most participants did not have interest in playing computer games, they were keen on playing simple health games (e.g., memory game) with their family members and friends over the Internet. One of the participants (IP4) who lives alone commented: “I like the idea of playing over the network because I do not have company here.”

Although only two participants (IP4 and IP5) of the study indicated that they experienced loneliness, there is evidence confirming that a large number of seniors live alone (Statistics New Zealand, 2007) and many suffer from social isolation (3News NZ, 2011). There is also mounting evidence indicating that loneliness is a serious concern among seniors in general. Hence, such information necessitates development of more interventions to enable seniors to deal with loneliness.

It is worth mentioning the cultural differences observed between the participants. The Indian and Asian participants were living in their own homes with their children whereas the European participants had children but they choose to live independently in retirement homes. The Asian participant and two Indian respondents shared that they are living with their own children, as it is their tradition that children take care of their parents when
they grow old. Therefore, the lifestyles of seniors are tied with their family values and traditions.

It is very important to design the pages of a web-based telehealth system in a linear way in order to guide users and simplify interactions. The interface needs to be attractive, clear and simple in order to be useful for seniors. Our study suggests that seniors prefer visuals over text. They like buttons or icons more than hyperlinks. If possible, every button (or icon) in the system should be presented with a suitable image and text. Every aspect of the system should be user-friendly and easy. Since remembering passwords is a major problem for seniors, we should use graphical passwords in the system, i.e. display keypad which allows users to memorise a visual pattern rather than a number sequence (Biddle et al., 2009).

Interview results indicate that social support through Facebook-like features is useful, as long as an online community of like-minded users exists. Social interactions can be used to reduce loneliness, motivate each other and share experiences. One participant (IP3) stated: “Talking is necessary to know other persons’ disease, so that the person feels that I am not alone.” Care must be taken that users choose professional advice for critical decisions, e.g. involving usage of medication.

One important result is that even existing computer users are less likely to use computers with increasing age. Three older participants (range age 77 to 87) made it very clear that they support the idea of managing health via the web-based telehealth system but they are not sure if they will use the system. They are very comfortable with their existing practices of managing their health. In a way, they feel managing health using the computer is a burden. This was an interesting finding but more than half of them were keen about the idea. It seems that the younger seniors were more keen to use a computer-based system to manage their health.

4.5. Conclusion

This chapter provided details and results of the first user study that was conducted with our target group. Initially, it was not clear how seniors would react towards the idea of using a computer-based system for health management. Their involvement in the study was insightful. Even though the present study is based upon a small sample size, it provides a good insight into respondents’ lifestyle, which helps to determine their expectations towards current web technologies to support their healthcare. Apart from understanding the user interface and functional requirements, they helped indirectly provide a better
understanding of the direction of the research.

Although we did not show or suggest other platform alternatives to the participants, we did not receive any negative response towards a web-based solution. The majority of them were active computer users after all and were keen with the idea of using a web-based healthcare solution. Hence, the interview results support our hypothesis that the Internet is a suitable platform to deliver telehealth applications. The interviewed seniors suggested several applications such as diet control, suitable exercises for different health problems, and simple network games to play with their families. They generally preferred a user interface layout which is clean, icon-based and colourful, and uses a horizontal menu at the top, which makes it easy to identify and choose key functionalities.

Our study also indicates that users' computer usage decreases with increasing age and they are less likely to change their current practice of depending on their doctor for monitoring and managing their health.

Now that we have had a good understanding of the UI and functional requirements of HC4L, and perceptions of seniors towards a web-based health application, in the next chapter we describe the design details of the system.
5. Design

In Chapter 2, we discussed shortcomings of existing consumer health informatics applications and features necessary to improve their effectiveness. Based on those requirements, we developed a framework for a patient-centric telehealth system, HC4L, presented in this chapter. Unlike the taxonomy presented in Chapter 3 (i.e. classification/categorization of the common barriers to telehealth), the HC4L framework is the essential supporting structure of our solution to address shortcomings of existing consumer health informatics applications, and hence it represents the basic structure underlying the HC4L system or the concept. This chapter also includes description of a functional prototype realised using the framework which will be used in Chapter 8 and 9 to evaluate the overall concept and its feasibility with target users.

Section 5.1 presents the conceptual framework that provides an abstract view of our solution to overcome the design limitations of current consumer health informatics applications. Section 5.2 lists and describes general principles to aid the final implementation of HC4L prototype design. Section 5.3 elaborates on the prototype design which covers details of its functionalities and user interface. Excerpts of this chapter have been published in Singh et al. (2010a) and Dhillon et al. (2013b).

5.1. HC4L Framework Design

In this section, we describe a conceptual framework to aid development of novel patient-centric telehealth systems. The framework presents the big picture (i.e. the overall vision including possible future work) for overcoming the challenges of existing consumer health informatics applications in enabling health consumers to take better care of themselves.

The framework combines the power of social media with telehealth systems to enable patients to take charge of their own health. Its goal is to transform the restricted nature of traditional telehealth systems by making them widely available, affordable and extendable. The framework, as depicted in Figure 5.1, consists of five parts: (1) applications and
services, (2) monitoring devices, (3) health data, (4) social and clinical networks, and (5) intuitive user interfaces. The following sections describe the framework components in more detail; they result from the previously discussed requirements and design principles.

**Figure 5.1.:** Conceptual framework for HC4L.

### 5.1.1. Applications and Services

The core functionality emphasised in the framework is the access to a variety of health-related applications and services, which are not limited to a particular disease or health condition. Hence, the framework has an open architecture which allows third-party providers to add new content and functionalities. The framework presented in Figure 5.1 covers a huge scope making it difficult to imagine how the system should look like. Figure 5.2 is a block diagram that gives an explicit view how the system will look like. It helps to inform that most of the features mentioned in the HC4L will be presented via health support applications that will be contributed by applications developers. This allows users to choose new monitoring and exercise tools when getting tired of existing ones. It also makes it possible to incorporate novel technologies, such as new HCI (Human Computer Interaction) devices such as iPhones, Wii remote and Kinect. HC4L can be extended with new applications that will be useful for education, monitoring, prevention,
diagnosis and rehabilitation in the form of, e.g., serious games, interactive web pages and expert systems. Good examples of a suitable architecture for our framework are social networking middleware frameworks such as the one provided in Facebook, where new functionalities can be added and shared with users. HC4L will need services supporting interoperability of different devices and applications.

One problem of an open architecture is the difficulty of verifying and testing content. These problems exist already with existing online healthcare applications. Facebook is making use of five-star ratings (Darwell, 2012) and YouTube uses a simple binary rating system, i.e. thumbs up or down (Mello Jr, 2012), that allow users to rate the quality as well as view the popularity of a social content and a community-contributed video, respectively. Similarly, we suggest employing a ranking system which displays user satisfaction and popularity of each service. However, care has to be taken to avoid attackers from manipulating the rating system (Feng et al., 2012). The ranking system should contain separate scores from patients and registered clinical/academic users.

Third-party providers or developers could be attracted to HC4L through several avenues. A large number of developers enjoy contributing to society with the knowledge that their work will be used and appreciated. This can be seen from the large number of successful open-source projects (Deshpande and Riehle, 2008, Pingdom, 2009). Developers will have the chance to have their names publicly associated with their applications. Applications could also be allowed to direct users towards commercial products with more features and functionalities, e.g. iPhone store apps. Low quality applications and advertisements would likely be outranked by more useful applications, and therefore have only little impact on the system. One could also consider granting special privileges such as “preferred developer status” and “research collaborator” which gives developers access to statistical data (in anonymised/aggregated form so that privacy is not compromised), which they can use for their own research projects. Another way to attract developers would be to implement a business model such as to sell applications/subscriptions and to allow small spaces for advertisement.

### 5.1.2. Health Data

A major problem with existing healthcare applications is that monitoring and activity data is not shared between applications. This makes it difficult to give users a comprehensive view of their health or total activities. This is in particular the case for exertainment applications such as Wii Fit. Once the user gets tired of the application and uses another game the activity data is lost. We therefore suggest to store and manage patient data inde-
pendent of the applications using it. This necessitates a common interface/structure, e.g. by using an XML (Extensible Markup Language) style language which we provisionally term “HealthML”. The language must be extendable and must contain unifying data elements in order to compare related types of data. For example, activities such as walking outdoors, Wii Virtual Tennis or iPhone Bowling could be compared using a “calories burned” or “perceived-level-of-exertion” scale (Borg, 1982) similar to those in some gym cardio machines.

Access control of data is an important aspect to realise the sharing of health data between applications. The system should let users decide what data to share with whom and complement with other provisions for privacy and against data theft/misuse. For example, one possible provision could be that applications can never obtain the real identity of a user (although this is still fairly weak since with even a partial profile, people might still be able to identify a user). There are specific database systems known as “hippocratic databases” that prevent people from getting identifying information (Grandison et al., 2008).

Another useful component of the patient data are the activity and action plans, which allow users to set and monitor goals, and discuss progress with health professionals and social contacts. These plans should be stored in a way that different applications can recognise and access them, e.g. an exergame application would automatically add values to an activity plan in the form of “calories burned”.

5.1.3. Monitoring Devices

Research suggests that consumers are highly interested in monitoring their health by using medical devices (Greenspun and Coughlin, 2011). In order to obtain monitoring data,
the system must have a flexible architecture to interface with a wide variety of medical and HCI devices. Professional medical equipment, such as blood pressure cuffs and glucose meters, should be supported but not be required. We propose to support as many consumer-level sensing devices (off-the-shelf devices owned and used by consumers in their day-to-day lives, e.g. for entertainment and communication) as possible. Examples are using the iPhone as the heart rate monitor, pedometer, walking distance recorder, and to detect falls. With the advent of cheap 3D and high-resolution webcams, we believe that in the next few years exercise monitoring and evaluation of skin parameters such as redness, swelling, and sweating will be possible. There is ongoing research by Mobahi and Karahalios (2005) on emotion recognition, which would be an important factor for monitoring mental health, stress levels, happiness, and depression. The system should still provide monitoring functionalities of traditional telehealth systems (Lee et al., 2011a) and offer easy to understand graphical feedback. The system should alert the clinician, care provider or family members if the patient’s clinical measures are found to be out of the acceptable range (Weitzel et al., 2009).

Arguably the most novel concept of the system is to make it ubiquitous. While traditional systems are designed as health informatics application, our goal is to hide the system’s functionality where possible. The user can employ system components (computer, PDA, mobile phone) for everyday activities and monitoring will be performed in the background. Examples are the analysis of keyboard and mouse input (speed, reaction time, jitter in mouse movement, typing errors) and of webcam data (emotions, redness, excessive sweating). When using an iPhone, the distance walked, number of steps, and falls can be detected (Boyce et al., 2012). In addition, unusual patterns in behaviour could be detected, e.g. a sudden change to a more sedentary lifestyle. Hiding functionality could also make the system simpler and more suitable for beginners (e.g. novice users may feel less intimidated when dealing with the system/device) but could appear to be less powerful for advanced users. Along with the aforementioned features, the system should provide the necessary privacy provisions to encourage use.

5.1.4. Social and Clinical Networks

The framework puts a larger emphasis on social networks rather than clinical networks. Clinical networks are a standard component of commercial telehealth systems. Health consumers can contact doctors via email, phone or video link and discuss medical conditions and treatment options, but such services are usually expensive. The motivation for social networks is threefold: many patients, and especially seniors, suffer from loneliness
and social isolation. Social networks can help users get in touch with their family, make new friends, and discuss medical conditions with peers and support groups (Huijboom et al., 2009). The aim is to improve emotional health, which is essential for the overall well-being, i.e. the state of being happy, healthy, and satisfied. Social networks can also help with motivating the patient, e.g. by providing family support, or by doing monitoring tasks and exercises together via a video link or in a virtual environment.

5.1.5. Intuitive User Interfaces

Prevention and rehabilitation can only be successful if users regularly use the system. Hence, it must be made attractive, unobtrusive, easy-to-use and available to all users, young and old. This necessitates the use of Principles of Universal Design (Story et al., 1998) and most importantly the widely accepted W3C Web Accessibility guidelines (Web Accessibility Initiative, 2010) in making the system more suitable for seniors. Attractiveness is increased by making the system fun (games, social contacts) and useful (education, monitoring). Ease-of-use requires well designed interfaces and mental models enabling the user to understand the purpose and functioning of the system (see Section 3.2.2 on page 33). The idea is to develop intuitive interfaces that would realise effective user interaction by emphasising recognition rather than recall, e.g. enable users to intuit the navigation structure. Many important design concepts are already incorporated into commercial telehealth applications. Examples are multi-language support, audio instructions, useful reminders, icon-based interfaces, scalable fonts etc. (as discussed in Section 3.2.1 on page 31).

In order to keep overheads low the personal computer and portable devices represent the user’s “patient station”. Recent research by Manhattan Research (2012) indicate that seniors are increasingly leveraging tablets for health-related activities. HC4L could be designed to be accessible via tablets, i.e. to address the uncomfortable use of keyboard and mouse to some seniors (as indicated in Section 3.2.1 on page 31). In other words, different interfaces can be implemented, e.g. to make the system more suitable for seniors, touchscreens displaying large buttons could be used. In some cases even that will not be sufficient and control by voice recognition and/or other techniques would be preferable.
5.2. Key Design Principles

The understanding we gained from preceding chapters, i.e. shortcomings of consumer health informatics applications (see Chapter 2) and requirements elicited from potential users (see Chapter 4) as well as findings of a formative evaluation of the initial HC4L prototype (presented in Chapter 8) identified the following KDPs (key design principles) for designing a novel telehealth system. These principles are sorted by importance and are intended to facilitate the final implementation of HC4L. There may be other principles, but during our design process the following principles came up as particularly important.

**Open and extensible (KDP-1).** The system should offer a wide variety of health-related applications that are tailored towards the needs and preference of patients (see Section 5.1.1 on page 56). Otherwise, the content can become repetitive and uninteresting to users and result into only short-term lifestyle changes (a shortfall of consumer health informatics applications discussed in Section 2.5 on page 25). The system should be “open” so that third-party developers can contribute content via a plug-in mechanism. This principle also helps to eliminate issues related to vendor lock-in. However, it should be attractive for developers to contribute content and functionalities to the system, e.g. so they can receive useful feedback from their application users and the possibility for business models such as selling applications or subscriptions. A standardised approach is necessary to enable developers to create and deploy applications in the system, i.e. guidelines for developers for creating compatible content. Preferably, they should be allowed to create applications using any programming language.

**Ubiquitous and affordable (KDP-2).** The system must be accessible online for free via a common web browser. As discussed in Section 1.1 on page 1, the Web is becoming a promising and cost-effective medium for the delivery of health-related services as the numbers of seniors actively using the Internet is increasing. Hence, a personal computer can be used as a patient station (see Section 5.1.5 on the preceding page) and mainstream devices already owned by consumers can be leveraged for managing their health, instead of creating another expensive device for the same purpose (see Section 5.1.3 on page 58).

**Social and emotional support (KDP-3).** The system should create a caring community, enabling users to provide and obtain social support to and from other users (see Section 5.1.4 on page 59). Social support is a general requirement for novel telehealth systems (as presented in Section 3.4.4 on page 41), which means that the system should be a social network at the same time. Research suggests that seniors are more prone to loneliness as they are likely to face stressful life course transitions, e.g. physical changes,
loss of friends and family, health problems, and disabilities (Cornwell and Waite, 2009). Long-term loneliness can lead to serious health problems and even death (Miller, 2011, Kim, 2012). Social features can be incorporated in the system to enable users to become friends of other patients (that have similar health conditions and interests) to make them feel that they are not alone, to perform health-related activities together (e.g. playing a memory game) and to motivate each other.

Feedback and motivation (KDP-4). The system should provide users with feedback on their health progress (as discussed in Section 3.3.2 on page 37) and motivate them to become more involved in their health by making behavioural changes such as improved compliance and positive lifestyle changes. Visual feedback via easy-to-understand graphs and charts can enable users to understand their health better. Furthermore, behavioural feedback could be useful to encourage users to make effective use of the system, e.g. making regular visits to track their exercises and vital signs. Such feedback could be motivational or purely data driven (i.e. in the form of a score) and provided within an appropriate periodicity (Gibbons et al., 2009).

Privacy control (KDP-5). Users should be provided with the ability to easily customise their privacy settings, i.e. to take control of who can view their personal information (this includes all information about them, also posts) (see Section 5.1.2 on page 57). It is apparent (from Section 4.3.3 on page 47) that some seniors are concerned about their privacy online. Therefore, users should be identified using a preferred username instead of their real name in the system. Sensitive health data such as diagnosis, symptoms, and treatments, should not be presented to others without the explicit permission of the user.

Personalised user interface (KDP-6). It should be possible to easily customise the system to present users with different applications that are tailored towards individual preference (see Section 5.1.5 on page 60). Seniors get overwhelmed when confronted with a plethora of functionalities (crowded UIs), especially those that are irrelevant to them (from the user study presented in Chapter 4, Section 4.3.4 on page 47). Users should be allowed to customise their user interface based on personal healthcare goals, e.g. to easily add health applications to and remove them from their profile. Sufficient information about available applications should be provided to enable users to select desired functionalities.

Simple navigation structure and clear instructions (KDP-7). The system should follow a simple navigation structure (see Section 4.3.5 on page 50) and offer a small number of tasks for an activity, e.g. the system should allow users to complete a health-related activity such as tracking their weight using a linear sequence of simple steps. Furthermore,
as indicated in Section 3.2.2 on page 33, users (especially first timers) should be guided with clear instructions about how to use the system. Such design is essential in enabling users to understand the interaction flow and to easily navigate through the system.

**More graphical than textual (KDP-8).** The main functions should be presented using both text and suitable graphics such as icons. Adequate icons are easily identifiable on the screen and reduce error rate (see Section 3.2.3 on page 34). An icon-based menu which uses bright and distinctive colours is useful - it adds value to the user interface, making it attractive and appealing to seniors (see Section 4.3.4 on page 47).

### 5.3. HC4L Prototype Design

In order to achieve the maximum impact on users’ health, a telehealth system implementing the framework must support a wide variety of devices and must offer a large amount of content addressing the requirement of different users. In order to test the presented concept we developed a prototype targeting seniors interested in improving their overall well-being.

The HC4L prototype went through several design revisions: from a paper-based prototype (evaluated in Chapter 4) to a first working version (evaluated in Chapter 8), to a final version (evaluated in Chapter 9) before the final design presented in this section was achieved. This section describes the design of the prototype with a focus on its functionalities and user interface. The prototype can be divided into two parts: HC4L (the system itself) and HC4L applications (health applications developed and integrated with the system).

#### 5.3.1. The HC4L System

The ultimate aim was to test if the concept of HC4L will work for seniors. Hence, we developed a prototype that was tested to determine the feasibility and acceptance among target users. The priority was to build the foundation of the system, which was a system which is ‘extendable’ by third parties. If the system was not extendable, then we had been stuck and not able to do much.

The HC4L system represents the interaction point where base functionalities of our HC4L framework are presented to the users. HC4L was designed to be accessible over the Web via a common browser (refer KDP-2 and Section 5.1.5). The functionalities implemented in this prototype were chosen based on priority. The primary focus was to
Figure 5.3: Content and navigation structure of HC4L.
build the foundation of the system, which is ‘extendable’ by third parties, i.e. enabling third-party developers to contribute new content and functionalities to HC4L. Without such feature, we had been stuck and not able to do much. Therefore, apart from designing a user interface for health consumers, a separate interface was created for developers to add applications to the system. Figure 5.3 on the facing page illustrates an overview of the content and navigation structure of HC4L.

Based on the results obtained from the user study presented in Section 4.3.4 on page 47, we have designed a user interface which employs large-sized fonts, an easy-to-follow linear structure (refer KDP-7), and an icon-based horizontal menu (see Figure 5.4 on this page) at the top of the screen to make it easy to identify and choose key functionalities (refer KDP-8). New users are closely guided to use the system (refer KDP-7). For example, after signing up with the system, users are encouraged to locate and add existing members of HC4L as friends and/or invite their own friends to join them in HC4L (see Figure 5.5 on the current page). In the following sections, information on key functionalities provided to consumers and their design decisions are described.

Figure 5.4.: Main menu depicting key functionalities of HC4L with mouseover effect on the Friends icon.

Figure 5.5.: Users are closely guided in using the system and immediate feedback is provided for each action taken by the user.
5.3.1.1. Activities

The *Activities* screen allows users to share information about their activities (i.e. generated by the health applications they use), and view and comment on the activities of HC4L friends. Its main objective is to enable users to motivate friends (e.g. for looking after their health) with positive comments (refer KDP-4). Similar to the “like” link provided in Facebook, users are equipped with a thumb-up button to provide a more visual form of support or encouragement. Such a form of encouragement is provided in DailyStrength.org\(^1\), where users encourage and support one another by sending a “virtual hug”.

Figure 5.6 on this page illustrates an activity update (i.e. a notification received by users that a friend has used a HC4L application) of a user, *Gamco*, that was received by his friend, *Jaspal*. In return, *Jaspal* responded with a thumb-up to encourage *Gamco* to track his health. Apart from that, if a user has not logged in for more than a week, a mail is sent to all friends that their friend may need more encouragement. MyFitnessPal.com\(^2\) uses a similar approach in enabling users to motivate and support each other for using the system to manage diet.

![Figure 5.6: The commenting and activity update feature provided in HC4L. Users can write positive comments and use the thumb-up button to encourage friends to look after their health.](image)

Figure 5.6: The commenting and activity update feature provided in HC4L. Users can write positive comments and use the thumb-up button to encourage friends to look after their health.

Measuring health is often a complex and daunting task due to the complexity and abstract nature of health itself. Hence, it is a challenge to quantify health into a single score. McDowell (2006) provided over 100 instruments to assess patients’ health with a discussion of their reliability and validity. However, it is not our intention to adapt or

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\(^1\) A social network focused on helping people overcome health and life challenges through advice and friendly support.

\(^2\) A free health and fitness community that helps users track nutritional intake and exercise levels.
5.3 HC4L Prototype Design

develop a new scale to measure health. Instead, we are interested in communicating the health-related performance based on the applications patients use in the system. The idea is to provide feedback to users on their health progress and to motivate them to continue leveraging HC4L for managing their health (refer KDP-4). Since HC4L is designed to be a generic system, a general score indicating overall health would be ideal.

A general score termed as *Healthcare4Life score* is presented at the top of this screen showing an overall performance measure of the user (as percentage) for the week to date (see Figure 5.7 on the current page). At this point, the score is aggregated from different categories of health applications used by the user, e.g. memory and exercise performance, and vital sign measurements, and provides an indication about the user’s progress in taking control of his/her health. Subscores (specific scores) are highlighted to allow users to know if they should to take an action. For instance, if the exercise score is low, it becomes apparent to them that they need to do more exercise to maintain good health. However, more research on formulating a single health score to indicate patients’ health in HC4L is to be carried out.

It is interesting to note that the commercial tool LifetimeHealthDiary.com\(^3\) also uses a single index called “total health score”. The score is computed using imported clinical data, device-derived data, and community-entered data, but no details are given on the underlying formulas. Since the company offers modules based on patient condition, data types to be imported, and the professional services that are to be offered, we assume that their computation uses more patient-specific parameters than our application.

![Your Healthcare4Life Score (14 May 2012 - 20 May 2012)](image)

*Figure 5.7.* The *Healthcare4Life score* is a summative weekly health score presented as feedback to users, motivating them in making effective use of the system. A higher score indicates that the user is making good progress in taking control of his or her health.

\(^3\)An application developed in New Zealand to engage patients in monitoring their own health and provides a single page summary of a user’s health information for clinicians.
5.3.1.2. Health Apps

As mentioned previously, one of the most essential features of HC4L is a large variety of health applications catering to users’ different needs and offering alternatives if users get tired of an application, such as an exergame (refer KDP-1 and Section 5.1.1). These applications are presented to the users via the Health Apps screen.

The number of applications in a framework like HC4L is expected to grow over time as application developers start to add content into the system. It is necessary to keep a good balance between the usability and functionality of a system (Calisir et al., 2011). Expanding functionality often results in a more complex system, which we identified as a factor reducing suitability of many existing Web 2.0 health applications for seniors (see Section 2.3.2 on page 19). Therefore, applications added by developers are grouped in an application directory. HC4L is a personalised system to some extent as users are not presented with the same set of applications, but are allowed to add desired applications (based on personal healthcare goals) from the Applications Directory to their profile and remove them at any time (refer KDP-6). A basic overview of each application and average user ratings are provided as guidance to aid users in deciding which application they should add to their profile (see Figure 5.8 on the next page). Figure 5.9 on page 70 depicts how the applications are presented to users when they are added from the directory. The idea of letting users add and remove applications to and from their profiles is to give them more control of the system and to allow them to customise the functionality of the system. In other words, a good balance between the usability and functionality of the system should be achieved.

5.3.1.3. Profile

The Profile screen of HC4L enables users to create a basic online health profile, which will enable other users with similar interests or health conditions to locate them in the system (refer KDP-3 and Section 5.1.4). Individual profile pages can be accessed by HC4L friends or all HC4L members, depending on the privacy options selected by the user. PatientsLikeMe.com uses a similar approach in enabling patients with similar (or dissimilar) health conditions to get in touch with each other. However, unlike PatientsLikeMe.com, information about the user’s health condition or diseases are not shown on this page to respect the privacy and confidentiality of the user (refer KDP-5).

In HC4L, users are closely guided to complete their user profiles (refer KDP-7). From Section 3.2.2 on page 33, it is apparent that we need to ensure the user understands how to
5.3 HC4L Prototype Design

**Figure 5.8.** Screenshot of the *Applications Directory* which lists all applications added by developers.

make effective use of the system. Therefore, clear instructions are provided next to each input box indicating how the entered information will benefit them and other users (see Figure 5.10).

The *Profile* screen allows users to specify an email of a family member or caregiver (e.g. nurse), which will enable the system to send alerts about users’ activities in the system. Recipients of the activity information (as discussed in Section 4.4 on page 51) can encourage the user to perform the necessary tasks (e.g. exercise and vital sign monitoring) and follow up if the user has not done them. The *Profile* screen also presents users’ recent activities in a similar manner as in the *Activities* screen. In other words, other HC4L users can see the recent activities of a user from this screen (subject to the privacy settings), enabling them to respond with encouraging comments and/or thumb-up (refer KDP-4). This is to allow users to check on the progress of specific friends in HC4L.
5.3.1.4. Mail

The Mail screen allows users to send mails to friends and other members in the HC4L network. This feature was created to enable users to discuss personal health-related issues with friends or other members of HC4L with similar experiences (refer KDP-3 and Section 5.1.4).

5.3.1.5. Friends

HC4L is a social network by itself, enabling users to build their own circles of social support in the system. The Friends screen mainly lists all HC4L friends of the user (see Figure 5.11). It provides core social networking functionalities, such as access to friends’ profile pages, finding and adding new friends, and inviting others to join HC4L (refer KDP-3 and Section 5.1.4). Similar to existing social networking sites (e.g. Facebook), users can submit, accept, and decline friend requests. Figure 5.12 on the next page illustrates the Member Search screen, where users can search for other HC4L users with similar health conditions, interests and location, and submit friend requests.
5.3 HC4L Prototype Design

Figure 5.10: Clear instructions are provided next to each input box in the Profile screen to inform users about the purpose of sharing the requested data.

Figure 5.12: Screenshot of the Member Search screen that allows users to locate and add other HC4L users as friends.
Figure 5.11: Screenshot of the *Friends* screen that lists HC4L friends of the user. The *Add More* button opens the *Member Search* screen (shown in Figure 5.12). Friends requests are listed at the top of this page.

### 5.3.1.6. Settings

Patient privacy is important (refer KDP-5) and users are advised not to share clinical information in HC4L. They are advised to avoid using their real name as part of their username during the sign up process. However, like with existing social networking and patient support websites, it is ultimately up to the user to decide what information to store and share. In order to make good use of the social networking features provided in HC4L, e.g. to find peers suffering from the same disease, it is necessary for the user to specify this information (when creating their online profile), and other members of such a patient group will hence implicitly gain this information. This is in contrast to PatientsLikeMe.com, which openly shares personal health information such as health condition, treatment and lab results with the community.

Users can change their privacy settings via the *Settings* screen, e.g. restrict their personal information to themselves, share the information with all HC4L members or allow only their HC4L friends to access the information (refer KDP-5). Figure 5.13 shows the screen for making changes to privacy settings.
Apart from making changes to the privacy settings, the Settings screen allows users to change their password and delete their user accounts. The screen is made accessible via the main menu, as suggested by participants of the formative evaluation (see Chapter 8).

**Figure 5.13.** Screenshot of the Profile Privacy Settings screen that allows users to restrict others from viewing their profile information.

### 5.3.2. HC4L Applications

In order to test the plug-in functionality of HC4L, several health-related applications were developed and integrated. The health applications in HC4L are created for common tasks such as tracking weight and physical activities, some of which are complemented with graphical visualisations of the collected data. Although each of these applications seems to be standalone, they use the persistence API (provided by OpenSocial) to store data on the HC4L system (see Section 7.2 on page 99), making it possible for other applications access to the data.

These applications were carefully designed with inexperienced users in mind and follow a linear structure. Each application has between two and four screens. As a motivation and feedback, all applications contribute to the Healthcare4Life score illustrated in Figure 5.7. Each application can be rated individually by the user (using a five-stars rating system, with one-star being the lowest rating), enabling the developers to get feedback from users. The average rating depicting the popularity of an application is displayed in the Application Directory as guidance for selecting applications. The following sections give an overview of the HC4L applications that were implemented for the prototype.

#### 5.3.2.1. Weight Tracker

Obesity among seniors in most developed countries is rising rapidly (Donini et al., 2012). Maintaining a healthy weight is essential in preventing and taking control of a host of
illnesses. Being overweight or obese is a leading risk factor for chronic diseases such as cardiovascular disease, diabetes and cancer (Newman, 2009) and is associated with an increased mortality in seniors (Donini et al., 2012). Similarly extreme weight loss (usually unintentional) can have deleterious effects on patients’ functional abilities and quality of life (Alibhai et al., 2005).

Weight monitoring can make users aware of any unhealthy weight changes, and help them to get back on track, e.g. by adjusting diet and exercise accordingly. We have developed Weight Tracker to enable users to monitor their weight. Users are expected to record their weekly or monthly weight values and a weight graph is plotted dynamically as visual feedback (see Figure 5.14), enabling users to see their weight trend and their progress in achieving their goal weight. Users can also see small successes more easily which could keep them motivated. The two common units for weight (kilograms (kgs) and pounds (lbs)) are supported in the application and the graph is plotted based on the selected unit.

![Figure 5.14.](image.png)

Figure 5.14.: Screenshot of the weight graph generated by the Weight Tracker.

The application does not use the BMI (Body Mass Index) to determine the goal weight; instead it allows the user to set their personal target. The BMI, commonly used to measure a user’s ideal weight, could underestimate body fat in older persons that have lost muscle mass (U.S. Department of Health and Human Services, 2005) and it could be unsuitable as a target weight, i.e. some users may find it unachievable and discouraging. Research
indicates that losing 5 to 10 percent of one’s initial weight is realistic and valuable (U.S. Department of Health and Human Services, 2005). Hence, the user is encouraged to discuss an appropriate target weight with their health professional.

### 5.3.2.2. Multiplayer Memory Game

There is growing evidence suggesting that exercising the brain can slow down memory decay, and a natural way of achieving this is through playing cognitively stimulating games. Playing memory games is a form of cognitive training and has also been shown to have a positive impact on an individual’s memory, learning and concentration, including seniors (Zwartkruis-Pelgrim and De Ruyter, 2008, Finn and McDonald, 2011).

The standard card game commonly known as concentration or memory game can provide an indirect measure of and train short-term and working memory of players (Jimison et al., 2004, Jimison and Pavel, 2006). According to Mubin et al. (2008), seniors are keen to play such simple games that have uncomplicated rules and their preference is to play them in teams.

We have implemented a social memory game that can be played remotely by two users located at different locations. Players are expected to find matching pairs of cards from a stack of shuffled cards placed face down on a surface. Players can click on up to two cards at a time to see them, and then have to remember the locations of these cards in order to identify two matching cards (see Figure 5.15). Instructions on how to play the game are presented to users before starting the game. The player with the most matched pairs wins the game.

Users can either challenge someone or play the game collaboratively. In the latter case both players of a team get a team score. In the first case, each player gets an individual performance score. The team play option was created to give novice players a gentle introduction to the game without having the pressure of challenging or competing with another user. The game score is calculated based on the number of matching cards found by the player(s) and the total time taken to find all matching pairs. The commonly available single player version of the game was not included in HC4L in order to promote social interaction among users.

### 5.3.2.3. Exercise Tracker

Regular physical activity and exercise are essential for healthy aging (Coltrera, 2010). Staying physically active and exercising regularly can prevent or limit the development
of chronic diseases and disabilities (Chodzko-Zajko et al., 2009). Although the exercise prescription for seniors should include aerobic exercise, muscle strengthening exercises, and flexibility exercises (Chodzko-Zajko et al., 2009), walking is an ideal exercise for this age group and results in defined health benefits (Department of Health and Human Services (HHS), 2008). However, it is necessary to track the amount of physical activity and exercise done to know if one has done enough for the week, as well as to add to the exercise plan or change it if necessary.

We have implemented Exercise Tracker, a tool designed to monitor the duration of exercise or physical activity users do and educate them about the amount of exercise they should do to look after their health. Users are advised to discuss an appropriate exercise goal with their health professional, which can then be specified as their target in the application. This is presented in the form of energy expenditure, i.e. the amount of energy in the form of calories. The default value for healthy individuals is 14 kcal/kg per week, which is a common measure used for a low/moderate intensity groups in STRRIDE (Studies of a Targeted Risk Reduction Intervention Through Defined Exercise) studies (Slentz et al., 2004, Slentz et al., 2007). The formula uses the current weight of the user, taken from the Weight Tracker, otherwise the weight can be entered manually.
5.3 HC4L Prototype Design

In terms of the user interface, the application uses a tabular interface with a list of common physical activities in the left column (see Figure 5.16). Such a design allows users to easily log the duration of different exercises they have done and allows users to enter or edit data for previous days or weeks, i.e. it reduces the need to enter data on a daily basis. Instead of getting the user to specify the intensity of the exercises performed, corresponding MET (Metabolic Equivalent of Task) values (Ainsworth et al., 2011) are used as a reference to approximate energy cost of physical activities. Two separate charts are presented as visual feedback: (1) the amount of physical activity performed (in minutes), and (2) the corresponding energy expenditure in calories. Each type of exercise or physical activity is presented with a different colour. Users are also provided with the option to view the chart for the week, month or year. Figure 5.17 on the next page illustrates the difference between a weekly and monthly chart.

The weekly Exercise score, a subscore of the Healthcare4Life score, is calculated based on the amount of exercise done by the user for the week, compared to the amount that should be done.

![Figure 5.16: Tabular interface of the Exercise Tracker for recording the user’s physical activities.](image-url)
5.3.2.4. Vital Signs Tracker

It is well established that regular tracking of vital signs is useful in identifying medical problems early and preventing them from becoming serious. Often, they are measured by health professionals and healthcare providers to spot potential symptoms and to make critical decisions about the patient’s psychological state. Basic vital signs such as body temperature, heart/pulse rate and respiration rate can be observed fairly easily and monitored by the patient outside of the clinical setting with the help of appropriate measurement devices and the vital signs tracker. The vital signs tracker allows you to see changes over time and indicates unusual values.

Unlike commercial telehealth systems that are designed to track patient health data which are transmitted to clinicians for follow up (as indicated Section 2.1 on page 11), we have developed a health tracking application called Vitals Tracker that enables users to monitor common vital signs and presents a graphical chart as immediate feedback on their health progress. In particular, the application allows users to track their BP (blood pressure, systolic and diastolic), resting heart/pulse rate, and fasting blood glucose. Similar to the Exercise Tracker, this application offers a tabular user interface, enabling users to enter data in a fairly direct manner (see Figure 5.18 on the next page). The vital signs chart presented in this application indicates whether the data entered by the user is within the normal range, which is highlighted in green (as shown in Figure 5.19 on page 80), making it easy to see the deviation from the desired range, if any. In contrast to typical tracker
applications found in smartphones, this application provides a summary of the users’ vital signs data on a single screen and allows the user to select from several views, e.g. 7 days, 1 month and 1 year. Users can track all or specific vital sign measures supported in this application. Figure 5.19 does not show any user data in the lower two graphs, indicating that the user only monitored his/her BP.

A weekly *Vitals score* that contributes to the user’s *Healthcare4Life score* is calculated based on how close the entered data is to the normal range of vitals. Full marks are provided if the entered data are within the normal range. For each vital sign measure, we obtained from the literature information about acceptable and critical values (Blood Pressure UK, 2008, U.S. Department of Health and Human Services, 2012, American Heart Association, 2012). In practice, these values depend on various patient parameters, and in future work, a more precise formula could be obtained from discussions with doctors.

![Figure 5.18.](image)

**Figure 5.18.** Tabular interface of the *Vitals Tracker* for recording the user’s vital signs data.

### 5.4. Conclusion

In this chapter, we presented the design of HC4L, which was developed to overcome shortcomings of existing consumer health informatics applications. The design principles
Figure 5.19.: Visual feedback about vitals data provided by the Vitals Tracker.

and framework design presented provide an overall vision of our solution and form a basis for a system prototype, where core functionalities were incorporated. Based on our understanding and experience from designing HC4L, designing a solution for seniors is a challenging endeavour. Seniors are often associated with difficulties in using technology, and the problem is compounded by their changing requirements, needs and expectations. Therefore, an iterative design process is essential in achieving a viable solution. Our design of HC4L is the outcome of a participatory design process that revolved around target users and their needs that could be considered for novel telehealth solutions. Now that we have described the design aspect, we evaluate relevant technologies that are suitable to realise a functional prototype of a web-based telehealth system in the next chapter.
6. Technology Selection

In this chapter we analyse Web 2.0 technologies for implementing a prototype of the previously introduced framework for a web-based extendable telehealth system with social networking capabilities. Specifically, we investigate the potential of popular social networking APIs and web development tools for fulfilling the requirements and design considerations for a general affordable telehealth system as described in the Chapters 4 and 5.

Section 6.1 reviews popular social networking APIs and Section 6.2 describes common web development tools. In Section 6.3, we discuss the advantages and disadvantages of technologies that could be used to realise HC4L. A brief overview about how the selected technologies can be integrated is included. Parts of this chapter were published in Dhillon et al. (2012a).

6.1. Social Networking APIs

Social networking APIs enable developers to integrate and enhance social features of a web-based application (e.g. the ability to find and communicate with other users of the application) by providing access to data shared by social networks. The Facebook and OpenSocial APIs are the two most popular examples. In this section, we describe and compare these APIs for the development of HC4L.

6.1.1. OpenSocial

OpenSocial provides a set of common APIs for developing web-based solutions, with a focus on social applications. It is currently managed by the non-profit OpenSocial Foundation, is developed by Google along with MySpace, and is supported by a number of other social networks and well-known software vendors such as Jive, SAP, SocialText, IBM, Nuxeo, and Atlassian (OpenSocial Foundation, 2013). The principle idea of OpenSocial is to make applications widely available to more users by enabling application developers
to deploy the same application across multiple platforms with no or minimum modification. Developers are also increasingly exploring OpenSocial for other development needs, moving from traditional social networking concepts to enterprise-level software (LeBlanc, 2011a).

OpenSocial allows the development of an open platform, also known as an OpenSocial container, where third-party developers can contribute applications written using the OpenSocial API. MySpace, Hi5 and Orkut are some of the popular OpenSocial containers. LeBlanc (2011b) reports a list of OpenSocial containers and implementers, both at the open-source and enterprise level, that take advantage of the services provided by the API. Examples of services are methods to access information about people, friends, and data, within the context of a container.

OpenSocial applications share the same structure as Google gadgets, and are therefore also known as OpenSocial gadgets. These gadgets are actually XML documents containing HTML (HyperText Markup Language) and JavaScript code along with metadata (Weitzel et al., 2010). There are two types of gadgets that can be built using OpenSocial: gadgets that live within the hosting container, and gadgets that rely on an external server. The latter is widely used in realising open platforms, where developers integrate XML specifications located on their own external web servers with the hosting OpenSocial container.

The contents of a gadget can be displayed in the different views supported by the container. Basically four different view types are defined in OpenSocial: profile, canvas, home and preview (see Figure 6.1) (Häsel, 2011). Gadgets can be specified to switch between these views to enable the users to interact with applications in different sizes and layouts. Most containers support the canvas view, which displays the rendered gadget by itself in a full-screen page within the container.

![Application views supported by OpenSocial](https://via.placeholder.com/150)

**Figure 6.1:** Application views supported by OpenSocial (from OpenSocial, 2010b).
To become an OpenSocial container that can render remote or embedded gadgets and support social networking features, a system must comply with both the Core Gadget Container Specification and Social Gadget Specification (OpenSocial, 2012). Developers can make use of Apache Shindig, which is a reference implementation of the OpenSocial standard. Apache Shindig is aimed at providing a language neutral mechanism for hosting OpenSocial applications with minimal effort (Apache, 2012). At the moment, Java and PHP versions are available. Apache Shindig provides the necessary code to render gadgets and proxy requests, as well as handle REST (Representational State Transfer) and RPC (Remote Procedure Call) requests to access social data (e.g. user data, friend lists, and activities) from a social site within an application.

Any HTML page can be fetched and displayed in an OpenSocial container using a gadget mechanism called Proxied Content. This implies that developers can specify the URL (Uniform Resource Locator) of any existing online application in the XML specification of an OpenSocial app, to turn it into a gadget that can be rendered by the container (OpenSocial, 2012). However, the outcome of wrapping existing applications in OpenSocial can be less rewarding, as these applications may not be designed to provide social interaction, unless the developer made significant use of the user’s social context, such as friend lists and activity streams (Hinchcliffe, 2011). OpenSocial gadgets are rendered by the surrounding container (e.g. Apache Shindig) and can communicate with their backend servers via JavaScript calls. Figure 6.2 on the next page illustrates the data flow that takes place when an end-user views an externally hosted OpenSocial application on a browser. The process can be simplified in four steps (OpenSocial, 2010a): (1) the end-user requests an application; (2) the container transmits the social data (via data pipelining) that is required by the application to the remote server (i.e. the app server containing the application); (3) the remote server responds by combining social and application data, returning HTML and JavaScript; and (4) the container sends the content to the end-user.

Although OpenSocial was not ready for productive use when it was launched in November 2007 (Schonfeld, 2007), it is rapidly evolving with more improvements and significant features. Recently, the OpenSocial Foundation has launched OpenSocial 2.0 (OpenSocial, 2012), which includes new features such as embedded experiences (embed content of another service into a container), activity streams standardisation, support for mobile devices, OAuth (Open Authentication) 2.0 and OpenSearch support (Hinchcliffe, 2011).
6.1.2. Facebook

Facebook is the most prominent social network and has more than one billion users worldwide (Vance, 2012). It was founded by Mark Zuckerberg and was initially a closed community open only to college students from recognised institutions, which was eventually made available to the general public. Developers are supported in building Facebook applications using the Facebook API. Similar to OpenSocial, this API allows applications to utilise profile, friend, photo, and event data to add social context. The Facebook API also allows applications to publish activities to the news feeds and profile pages of Facebook. Increasingly, Facebook is used by people and company sites as an identity provider with its support for OAuth 2.0 (Cain, 2011). This avoids the need to register or create a new user account on each site individually. The large user base of Facebook attracts many third-party developers who build new products and services on this platform.

Facebook applications rest entirely on their developers’ web server. The API allows developers to access social data from the Facebook databases and deliver custom content to end-users via Facebook servers. Facebook acts as a middleman for all interactions between application developers and end-users. Figure 6.3 on the facing page summarises the data flow that takes place when an end-user requests an application. The process begins when the end-user views an application through a Facebook URL (e.g. http://apps.facebook.com/appname). Facebook servers interpret input parameters and the application request and transmit their interpreted data to the corresponding application server (i.e. an external server from the app developer). In return, the application server performs requested actions including database operations and delivers an output page to Facebook (i.e. an HTML page and related scripts). Finally, Facebook delivers the interpreted output page to the end-user.
6.1 Social Networking APIs

Figure 6.3.: Facebook application data flow (from Lucas and Borisov, 2008).

The Facebook API supports the Graph API and the REST API to enable applications to read and write data to Facebook (Facebook, 2013). The Facebook platform is based on a URL-addressable, REST-like server API, i.e. it assigns unique IDs to each social object in the system, which can be invoked by a URL. The Graph API addresses many technical deficiencies of the old REST API (e.g. the need to make multiple API calls for a simple task) and makes it fairly easy for applications to post and consume data (Paul, 2010). Facebook is in the process of deprecating the REST API and encourages developers to implement new applications using the Graph API and to update existing applications to use it as well.

Until recently, Facebook restricted developers to proprietary languages such as FBML (Facebook Markup Language) and FBJS (Facebook JavaScript) (Facebook, 2012). The engineering team of Facebook has released and maintains open-source SDKs for Android, C#, iPhone, JavaScript, PHP, and Python (Facebook, 2013).

The use of the Facebook API for telehealth systems makes it possible to access millions of users of this social network, including the family and friends of a patient. According to Norval et al. (2011), this makes it easier to connect people known to a patient to provide care or social support. However, seniors remain a clear minority and in 2010 only 2% of Facebook users were in the 65+ age bracket (SocialBakers, 2011). On first impression, it may seem attractive to develop HC4L by using the Facebook API mainly due to its extensive user base, but existing literature (Lehtinen et al., 2009, Norval et al., 2011) and findings of the user study presented in Chapter 4 (see Section 4.3.3 on page 47) indicate that a lack of trust among older adults towards major social networking sites such as Facebook is still present.
The statistics from SocialBakers (2012) show that the three top categories of applications in Facebook are Games, Entertainment and Lifestyle. Health applications (a subcategory of Lifestyle) represented just over 1% of the total available applications. This indicates Facebook applications are predominantly focused on younger people, and developers are less interested in creating health support applications on this platform. A recent survey by Foresee, as cited by Tam (2012), shows that Facebook received the lowest rating in a customer satisfaction index comparing a number of social networking sites, while Google+ received the highest rating score.

6.2. Web Development Tools

The development and maintenance of web-based applications is simplified by using readily available web development tools. Two common approaches employed by web developers are CMSs (Content Management Systems) and WAFs (Web Application Frameworks). In this section, we highlight the strengths and weaknesses of their ability to support the design, implementation and maintenance of web-based telehealth systems.

6.2.1. Content Management Systems

CMSs support developers with setting up rich and dynamic websites. With a CMS, the content is stored in a database and the templates, styles or themes that determine how the content is presented, are maintained separately (Hartland, 2009). CMSs frequently leverage the power of CSS (Cascading Style Sheets) to update or make changes to the look and feel of websites. The main advantage of employing a CMS in developing a web-based system is the variety of ready-made modules, which can be directly used or adopted to add desired features to the website. CMSs can be integrated with existing social networking APIs. For example, Drupal has a module to integrate the OpenSocial API. Most CMSs use popular programming languages such as PHP to enable developers to create customised modules for specific features of their site. The three major open source CMSs are Drupal, Joomla and WordPress (“Open Source CMS Market Share Report”, 2009).

Drupal is one of the most popular and capable CMS available to develop dynamic state-of-the-art Web 2.0 sites. Drupal is supported by a large and active community of developers, and offers a large number of open-source extensions, modules, and themes. It is based on a customisable framework which enables its site visitors to contribute content. The provided functions go beyond those of a CMS, as it also acts as a framework
for developing web applications and is used in a wide variety of deployments. Drupal is increasingly used for developing social networking sites (Purham, 2010) and healthcare systems, including sites connecting patients to health services (e.g. Kosansh.com) (Drupal, 2012a).

Joomla is another strong alternative for rich web development. It is fairly easy-to-use, but most of the customisations required by the user are built around paid plug-ins and themes. It lacks important features such as a powerful blogging engine, nested categories, a built-in download manager, document repository, CCK (Content Construction Kit) abilities (functionality to easily move content around), and many other features already found in Drupal. WordPress has a strong focus on blogging, although a large number of open-source plug-ins are available to extend its functionality. It is ideal for fairly simple blog-style websites, but is not suitable for more complex site requirements (Quinn and Gardner-Madras, 2010).

Figure 6.4 on the following page provides an overview comparison between these CMSs. Generally, these CMSs have different capabilities and functionalities (in the form of plugins, extensions or modules) that can be installed by the user. Although WordPress has 12,000 plugins, Joomla’s 6,000 extensions and Drupal’s 7,000 modules offer significantly more functionality to their users (Wilding, 2011). These CMSs can be used to develop fully functional and professional websites or web-based systems, but the functionalities they offer may differ and suit a different user group. For instance, WordPress, which is known as an simple-to-use CMS, will be suitable for novice web developers, whereas Drupal, which is supported with fairly advanced modules (hardcore plugins), will allow developers to create complex web-based solutions.

### 6.2.2. Web Application Frameworks

WAFs (also known as web development frameworks) support developers with building websites, web applications and web services, by providing far more flexibility over how the site/application is put together than CMSs. WAFs provide functionalities that are common to most web applications, e.g. database access, session management and templating systems (DocForge, 2012). They help in providing a basic structure in developing web-based systems, which enables developers to reduce repetition and write code in a shorter amount of time. For instance, a framework enables developers to avoid the need to re-code the same features for each web application they create. There are many frameworks available for web development, written in various programming languages, with varying technical and conceptual differences (Singh, 2010). For example, Yii, CodeIgniter, Zend,
CakePHP and Symfony are just a few of the popular ones from the vast selection of PHP frameworks available to code web-based projects. Although each framework is different, they generally provide a variety of useful features.

Most WAFs are based on the MVC (Model View Controller) architecture (Supaartagorn, 2011). MVC implements a “separation of concerns”, i.e. distinct features without overlapping functionality. Examples include isolation of the application logic from the user interface and separation of database access code from the application logic. Separation of tasks, such as web programming from user interface design, allows a development team to focus on specific objectives and use their individual strengths (DocForge, 2012). With MVC developers can focus and work on individual elements. Hence, the concept of MVC helps to break the development process of an application down into manageable tasks.

6.3. Discussion

6.3.1. OpenSocial versus Facebook

Section 5.2 on page 61 showed that two major requirements of patient-centric telehealth systems for long-term health management are to make the systems extendable by third parties and to include social networking capabilities. There are two general approaches to realise such features: (1) creating a new API from scratch and sharing it with health
application developers, and (2) deploying and adapting existing tools that support development of an open platform with social interactions. The former is more difficult because it takes time for an API to mature and to be accepted as a standard by developers. When leveraging existing Web 2.0 technologies for creating open-ended systems, developers need to make a well-informed choice about the API used (Norval et al., 2011).

Social networking APIs are the core technologies needed to realise the open platform and social aspects of such a system. After reviewing the current social networking APIs, it is clear that both OpenSocial and Facebook provide social capabilities (i.e. allow users to access social data). Both APIs support integration of third-party applications, which can be developed using any language that supports web programming (e.g. PHP, Python, Java and C#). However, the APIs were created with different objectives in mind.

OpenSocial is not a technology but a specification. By following the OpenSocial specification any system can be turned into an open platform, which can interact with other applications in a standardised way. The platform and other applications will have a common set of interfaces and processes in order to communicate seamlessly. In contrast to OpenSocial, Facebook is a social network and does not provide an open platform. It uses a plug-in architecture that enables developers to create applications, which can only run within the Facebook platform.

As mentioned, our intention is to implement a telehealth system which is extendable by third-party developers to add content or health applications. It became apparent that OpenSocial provides such an ability. The main advantage of using OpenSocial is the availability of a stable reference implementation (i.e. Apache Shindig) that can be installed and configured to transform HC4L into an OpenSocial container ready to host third-party applications. Development of OpenSocial-based applications is fairly easy and attractive, since developers are not required to learn new programming languages; instead, common languages such as HTML and JavaScript can be used.

OpenSocial allows development of web-based telehealth systems without constraining the users with proprietary regulations. On the contrary, developers using the Facebook API have little control over the social network functionalities and will be confined by restrictions caused by its changing user policies (Norval et al., 2011). For instance, Facebook created new restrictions for game developers, prohibiting them from accessing its Open Graph on other platforms (Duryee, 2012). OpenSocial provides more flexibility to users in adapting it to their own requirements. Third-party developers will also have the freedom to integrate their applications with other OpenSocial containers. The ability to run applications on various containers will encourage potential developers to contribute
Chapter 6 Technology Selection

health applications. However, OpenSocial allows this to happen only if the applications are programmed to be generic, and do not use their own proprietary API (Häsel, 2011).

OpenSocial being open-source allows users to experiment with the API (e.g. to measure the success of a specific functionality among HC4L users). In contrast, research and development could be limited if support platforms such as HC4L are built using the API of a “parent” social network such as Facebook (Norval et al., 2011). Some usage data is inaccessible in Facebook. Certain usage data (e.g. number of users above 65) could be obtained, but we will not be able to tweak or make any changes to the API.

The idea of leveraging OpenSocial for telehealth systems was initiated by Weitzel et al. (2009), who described the use of this Web 2.0 technology in providing extended care networks for chronic disease management and senior care. Furthermore, Weitzel et al. (2010) discussed a Web 2.0 model for patient-centred health informatics applications. The suggested model uses open technologies such as OpenSocial, REST, and OAuth.

Based on the reviews and analysis, the OpenSocial API meets the requirements to develop online telehealth systems which are extendable and contain social aspects. It provides the necessary components and working code for transforming a typical web-based system into a social and open platform which is extendable by third parties. OpenSocial also provides a standard approach for creating gadgets or applications, i.e. guidelines that can be provided to developers for creating compatible content for an OpenSocial-based telehealth system. Table 6.1 on the facing page summarises our analysis and highlights the difference between the OpenSocial API and the Facebook API. Although Facebook is known to be the most popular social networking site, it is not necessarily an appropriate platform to deliver health-related services to consumers, especially to seniors.

6.3.2. Content Management Systems versus Web Application Frameworks

Using web development tools can considerably reduce development time, which is essential for complex incremental systems. The choice of using CMSs or WAFs depends on the complexity, requirements and duration of the telehealth project.

CMSs are basically built on top of a popular or in-house WAF and are aimed at making web development easy for developers (Bock and Luna, 2013). They are platforms installed by users on their web servers, which allow them to customise the default layout (i.e. choose from existing user interface templates or create a new theme) and begin adding content. In other words, CMSs provide the user with back-end support (e.g.
modules and themes) to develop and manage a website (front-end). Often, CMSs are supported with easy-to-understand tutorials (including video tutorials) to get started, install add-ons (functionalities) as well as to begin with writing custom code. WAFs are far more generic and programmer-oriented compared to CMSs, and they are suitable for creating highly customised web applications (Forma-Pro, 2010). Users deploying a WAF need to start creating an application from scratch by using the readily available classes and libraries. The initial learning curve for some of the WAFs can be quite steep (DocForge, 2012) and many WAFs require the user to have good background in OOP (Object Oriented Programming).

Developers using a CMS make use of or adapt available functionalities to create a web application. To some extent, developers depend on the functionalities provided in the CMS. There is evidence that developers have more control over the resulting outcome as they are able to see the forming end-product early, which they keep improving until the desired application is realised (Cheng, 2009). WAFs are more flexible than CMSs, providing flexible APIs that allow developers to customise almost anything and extend core capabilities (Kennedy, 2012). However, developers typically have lower quality control.

### Table 6.1: OpenSocial versus Facebook.

<table>
<thead>
<tr>
<th>OpenSocial</th>
<th>Facebook</th>
</tr>
</thead>
<tbody>
<tr>
<td>A standard specification (OpenSocial Foundation, 2013)</td>
<td>A social network</td>
</tr>
<tr>
<td>Steadily growing user base</td>
<td>Large user base (Norval et al., 2011)</td>
</tr>
<tr>
<td>Provides a reference implementation to create an “open” platform (Apache, 2012)</td>
<td>Closed-source implementation</td>
</tr>
<tr>
<td>API for social applications to run on multiple social networks (Häsel, 2011)</td>
<td>Single network API (Facebook, 2013)</td>
</tr>
<tr>
<td>Allows applications to be ported to various OpenSocial containers (Häsel, 2011)</td>
<td>Applications can only run within the Facebook platform (Graham, 2008)</td>
</tr>
<tr>
<td>Open with no proprietary regulations</td>
<td>Strict proprietary regulations (Duryee, 2012, Facebook, 2013)</td>
</tr>
<tr>
<td>Applications hosted can be client-side JavaScript-oriented (gadgets) or server-oriented (Weitzel et al., 2010)</td>
<td>Applications hosted are all server-oriented (Graham, 2008)</td>
</tr>
<tr>
<td>Full control over the social network functionalities and user policies</td>
<td>Little control over the social network functionalities and user policies (Norval et al., 2011)</td>
</tr>
<tr>
<td>Allows developers to experiment with the API</td>
<td>Limits research and development (Norval et al., 2011)</td>
</tr>
</tbody>
</table>
over the end-product due to the time involved in writing the code and creating a functional prototype (Kennedy, 2012). Hence, proper planning prior to programming an application using a WAF is essential (Cheng, 2009), because lack of planning can make it necessary to rewrite a lot of code and increase cost.

CMSs typically have built-in customisation functionality that allows users to update or make minor changes to their applications fairly easily online (via a back-end user interface), i.e. without having to use a development environment. This enables even non-technical users to make content updates or changes. By contrast, WAFs typically require a development environment to make any changes to an application, unless developers explicitly implement functionality for customising and extending the user interface. As such, CMSs are generally situated on a higher level of abstraction, using WAFs for their implementation and offering some customisation functionality for end-users through a pre-defined user interface. Table 6.2 summarises the difference between CMSs and WAFs.

<table>
<thead>
<tr>
<th>Content Management Systems</th>
<th>Web Application Frameworks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easier learning curve</td>
<td>Harder learning curve (DocForge, 2012)</td>
</tr>
<tr>
<td>Prior planning is useful</td>
<td>Prior planning is essential (Cheng, 2009)</td>
</tr>
<tr>
<td>Typical system updates can be done fairly easily (Hartland, 2009)</td>
<td>System updates may require substantial coding</td>
</tr>
<tr>
<td>Built-in support for customisation, e.g. using modules and themes (Wilding, 2011)</td>
<td>System built from scratch using available classes and libraries (Forma-Pro, 2010)</td>
</tr>
<tr>
<td>Suitable for projects that have relatively straightforward requirements, including system prototypes (Cheng, 2009, Kennedy, 2012)</td>
<td>Suitable for projects that have complex requirements (Cheng, 2009)</td>
</tr>
<tr>
<td>Flexibility within the parameters and extension points of the CMS</td>
<td>Unlimited flexibility (Forma-Pro, 2010, Kennedy, 2012)</td>
</tr>
<tr>
<td>Can provide a functional system early on if required modules are available (Forma-Pro, 2010, Kennedy, 2012)</td>
<td>Typically require longer development time due to required coding work (Kennedy, 2012)</td>
</tr>
</tbody>
</table>

In this project, we require functions that allow end-users to customise and extend a website. Furthermore, we want to make use of our preferred social networking API (i.e. OpenSocial). Finally, it must be possible for us to create and refine functional prototypes of our system quickly, to accommodate the time and resource constraints of this research project. According to the characteristics of CMSs and WAFs, as presented in this chapter, these requirements favour the use of a CMS rather than a bare WAF as a basis for HC4L.
Drupal is a modular and powerful CMS that offers more functionality than other available CMSs. It encompasses more than 11,000 contributed, tested and documented modules (Drupal, 2012b), including modules to integrate HCI devices such as webcams (Drupal, 2012c). Therefore, it is likely that the functionality required in HC4L is already available there. Drupal provides a hybrid approach, offering the advantages of both WAFs and CMSs. For instance, as a CMS, Drupal enables rapid prototyping of applications and similar to some WAFs (e.g. Ruby on Rails), it includes built-in unit testing for developers to test specific pieces of code (Kennedy, 2012). Among other benefits, Drupal is preferred over many other CMSs and WAFs because it has a contributed module called OpenSocial Shindig-Integrator that can be used to integrate the Apache Shindig OpenSocial container (Sharma, 2009), so that an extensible web-based telehealth system with social capabilities can be achieved.

6.4. Conclusion

In this chapter, we explored popular Web 2.0 technologies for implementing HC4L. We have specifically investigated the OpenSocial and Facebook APIs, and a range of web development tools with respect to the requirements presented in Chapter 5. In particular, we want technologies that can realise a telehealth system which is extendable by third parties and incorporates social networking capabilities. We also investigated other advantages of leveraging the aforementioned technologies for HC4L.

Our results show that Google’s OpenSocial technology provides the necessary tools such as Apache Shindig (a reference implementation of OpenSocial) that enables ordinary systems to host applications from third parties. Unlike Facebook, OpenSocial is not controlled by a single vendor, hence it does not constrain developers to proprietary regulations (e.g. developers can experiment with the API). The Drupal CMS is equipped with advanced modules including the Shindig-Integrator that can be used to integrate Drupal with Apache Shindig. Both OpenSocial and Drupal are supported by a large and active community, and provide access to the resources (e.g. working code) and support (e.g. forums) for implementing our system. Therefore, we use these technologies to realise a working prototype of HC4L. Details about the implementation are given in the following chapter.
7. Implementation

In the previous chapter, we noted the benefits of leveraging OpenSocial and Drupal for developing an open-ended web-based telehealth platform. This chapter presents how these technologies were employed in realising a working prototype of HC4L. The content of this chapter will benefit other developers and researchers interested in using OpenSocial and Drupal for their implementations.

Section 7.1 describes how the system is designed as an OpenSocial-based container. Section 7.2 describes the type of applications that can be hosted on HC4L. Section 7.3 summarises technical issues encountered during the development. Excerpts of this chapter have been published in Dhillon et al. (2012a). The resulting system of this project was accepted as a demo in Dhillon et al. (2012d).

7.1. HC4L Container

One of the key challenges behind the implementation of HC4L is the development of the plug-in feature that will enable developers to contribute health applications. OpenSocial with Apache Shindig (its infrastructure provider) allows development of such a system (Apache, 2012). The ideas presented in Weitzel et al. (2009, 2010), along with our review on current social networking APIs (see Chapter 6) affirm the value of leveraging OpenSocial in the development of HC4L.

Initially, we started the implementation process by installing Partuza (not available anymore), shown in Figure 7.1 on the next page, which was an OpenSocial-based sample social networking site launched in 2008 by Google. Partuza was written in PHP and was available under the Apache open-source license. This example container had an abstraction layer for Apache Shindig built-in, which allowed users to seamlessly integrate OpenSocial gadgets (LeBlanc, 2011a). A live Partuza site was also available for users to test the URL of the gadget. We tried to adapt Partuza to meet the user interface and functional requirements of HC4L, but later realised that there were missing source code, no documentation support, and the program was no longer maintained. Therefore, we did
not use Partuza and implemented the HC4L container by ourselves.

**Figure 7.1.** Screenshot illustrating the user interface of Partuza, which was a sample PHP OpenSocial-based social site aimed at enabling developers to use Apache Shindig to add OpenSocial support to their sites.

We adopted PHP as our main programming language, as we employed the PHP version of Apache Shindig and the PHP-based Drupal CMS (version 6.2) to realise the system. The resulting system supports both application users and application developers. Both groups are presented with distinctive functionalities based on their role in the system. The core functionality provided to application developers is to embed their applications into HC4L and to receive feedback from users. Applications can be added into HC4L via Drupal’s admin user interface or through a separate user interface specifically designed for the developers.

We designed a customised theme for HC4L (shown in Figure 7.6 on page 106) using HTML and CSS, which was imported into Drupal. Although Drupal comes with lots of design templates, we opted for a new theme based on the derived interface design requirements (see Section 4.3.4 on page 47). We then installed and activated existing Drupal modules for many of the functionalities of HC4L. For instance, we employed the *Flag* module for storing data, e.g. information of friends and activities, and the *Webforms* module for developer and user registration. We also created customised modules for features not supported by the existing modules. For instance, Drupal does not support different types of registration for developers and normal users, which is required for HC4L.

Upon implementing the basic functionalities, we integrated OpenSocial with Drupal
to transform HC4L into an open platform. Apache Shindig was installed within the HC4L environment and was integrated with Drupal via the *Shindig-Integrator* module. Figure 7.2 depicts the plug-in architecture of our system.

![Figure 7.2.](image)

**Figure 7.2.**: Plug-in architecture of HC4L. The Apache Shindig was integrated with Drupal via the *Shindig-Integrator* module to realise an OpenSocial-based container for hosting third-party applications.

We made some adjustments to adapt the *Shindig-Integrator* module with HC4L. In HC4L, we have used the *Flag* module for a user’s friends’ data and the *Content-profile* module of Drupal to store a user’s profile. The *Shindig-Integrator* module originally used the *User Relationships* and *Profile* modules for a user’s friends and profile, respectively - both of which were upgraded to the latest version of Drupal. Hence, in order to integrate the *Shindig-Integrator* with our platform, we adjusted the code to use modules we have used in HC4L. The *Shindig-Integrator* has a class which talks to the database for retrieving a user profile or user’s friends based on the user ID and this class was amended accordingly.

Figure 7.3 on the following page illustrates the OpenSocial reference architecture that provides an overview of the involved technologies and components, and interactions between these components. HC4L conforms to this reference architecture. The existing social networking software referred in the diagram in our case refers to Drupal. We have connected Drupal with Apache Shindig’s OpenSocial SPI (Service Provider Interface) to allow OpenSocial applications to access our site’s social data. In particular, the applications and Drupal exchange three kinds of data described below. In other words, these are the three basic services that HC4L offers to its applications:
1. **People/Relationships** - To have access to the connections between people and their friends in the network (i.e. social graph), in enabling an application to support the exchange of information and the interaction between users.

2. **Activities/Notifications** - To inform others about the activities of a user, i.e., interactions between a user and an application.

3. **Persistence** - To store data about a particular user, e.g., the scores achieved in a Tic-tac-toe game application, which can be retrieved when the application runs again at a later time.

![OpenSocial reference architecture](from Häsel, 2011).

Communication between Apache Shindig and HC4L takes place via standardised AJAX (Asynchronous JavaScript and XML) requests, defined in the OpenSocial JavaScript API (OpenSocial, 2012). The hosting process of HC4L via Apache Shindig is made possible through the following components (Apache, 2012):

1. **Gadget Rendering Server** - Renders the gadget XML (i.e. the definition for a gadget) into JavaScript and HTML in order to expose it via the container JavaScript, usually as an `<iframe>` element.

2. **OpenSocial Data Server** - Provides a mapping implementation of the server interface to the container, including the RESTful API, for developers to connect it to their backends (i.e. enabling developers to implement their own data syncs).

3. **Gadget Container JavaScript** - Manages the basic gadget functionality including security, communication, and user interface.
4. **OpenSocial Container JavaScript** - JavaScript environment that sits on top of the Gadget Container JavaScript and provide the OpenSocial functionalities (e.g. profiles, relationships and activities).

Care has to be taken when enabling third-party applications to access social data of our system (i.e. secure communication between the third-party applications and HC4L) by implementing the necessary security and privacy mechanisms (Häsel and Iacono, 2010). Apache Shindig provides a variety of security level options to secure requests and responses, i.e. enabling developers to make applications more secure. It uses Shindig user security tokens, two- and three-way handshakes, OAuth, and various encryption technologies.

### 7.2. HC4L Applications

Since HC4L is now an OpenSocial container, third-party developers can contribute content and functionalities, as long as they are OpenSocial-based applications (version 0.8) or packaged as such. Generally, there are two broad categories of applications that can be hosted on HC4L: client-side (i.e. lightweight applications that do not rely on a server) and server-oriented (i.e. applications that rely on an external server for processing and rendering data). Both types of applications execute within the HC4L container but differ in terms of the functionality they can provide to users. Client-side applications are created using HTML, JavaScript, CSS, OpenSocial Templates, and/or Flash. They are known to provide limited functionality and typically use the OpenSocial persistence API to store data in a container. Server-oriented applications can realise advanced applications, which can be developed using any technology, e.g., HTML, JavaScript, CSS, OpenSocial Templates, Flash, PHP, Python, Java, Perl, .NET, or Ruby.

All applications should provide the standard XML specification file (shown in Figure 7.4 on the next page) that defines an OpenSocial application. This file is the starting point of an application and defines details such as title, author name, author email, description, height and width, and image paths. It also includes CSS and JavaScript code. OpenSocial (2011) provides a general reference point for developers to implement applications that can run in an OpenSocial-based container such as HC4L.

Third-party applications can be deployed in HC4L via the developers’ user interface provided in HC4L or the Drupal’s admin interface (see Figure 7.5 on page 101). Developers can add applications that reside on their own web servers by simply specifying their URL, i.e. the location of the XML file of the application. Application developers are
also requested to select a suitable application category, e.g., monitoring, diagnosis and rehabilitation (as discussed in Section 5.1.1 on page 56), which will be useful to group the applications in the system. Each application added will be listed in the application directory of the system.

The application will be rendered in canvas view (full-screen view) on the client side by Apache Shindig via the Shindig-Integrator module. We have tested this feature by hosting a third-party application called Calorie Calculator from LabPixies.com\(^1\) (see Figure 7.6 on page 106). This is a lightweight application that does not rely on a server but uses the persistence API to store data in our container. Hence, it is possible to plot a graph of the calorie intake of a user for each week/month/year by using these data, and other applications in HC4L can also have access to these data.

We also created and added several applications ourselves: Weight Tracker, Exercise Tracker, Vitals Tracker and Multiplayer Memory Game. These applications were implemented using AJAX. JSON (JavaScript Object Notation) was used to get back a response in object form and HTTP as the transport mechanism for getting a request to a server, and getting the response back. The Google Charts API was used for generating the graphs or charts in applications.

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\(^1\) A company (acquired by Google) that develops personalised web gadgets (also called "widgets") for various platforms including iGoogle, Android and the iPhone.
7.3 Implementation Issues and Challenges

The design and implementation of the HC4L prototype together with several OpenSocial-based health applications demonstrate that OpenSocial and Drupal integrate well and can be used to develop extendable online telehealth systems with social capabilities. Based on our analysis, implementation experience and understanding, the requirements described in Chapter 4 and 5 can be achieved by leveraging these technologies. Below, we discuss the strengths and weaknesses in employing OpenSocial and Drupal.

Figure 7.5.: Screenshot illustrating the user interface to add applications via the Drupal admin page. Note: This user interface will not be used or seen by the health consumers.
7.3.1. OpenSocial

The availability of Apache Shindig, the reference implementation of OpenSocial, has helped to turn HC4L into an OpenSocial container that can host health applications created by external developers. Theoretically, developers can program their OpenSocial compliant websites (containers) using any programming language as long as the OpenSocial specifications are satisfied. In practice, however, many developers leverage Apache Shindig, which supports only Java and PHP (Apache, 2012).

It is fairly easy to develop gadget applications since common languages such as HTML and JavaScript are used. Most available documentation explains only basic steps to get started with the development of a gadget application and only covers the basic operations, such as retrieving the users’ friends from their social network and giving “gifts” to their friends. Only few tutorials are available for developers to implement complex applications requiring server-side logic, such as applications that enable users to interact with each other (e.g. a multiplayer memory game). Therefore, we had to invest a lot of time in experimenting with the API to implement other functionalities such as retrieving and updating a user’s game state of our multiplayer memory game.

Furthermore, applications must use a compatible version of the specification, which specifies the features that we want the hosting container to support (OpenSocial, 2012). Issues with compliance arise when rendering applications implementing the 0.9.x version of the API, as the Shindig-Integrator of Drupal is only available for version 1.0. Also, we found that designing a gadget for a specific container may require modification when running it in other OpenSocial-based containers (due to the different versions of the OpenSocial specification available). The ability to run applications in various containers may not be crucial for a system such as HC4L, but such feature can encourage potential developers to contribute health applications. Hence, the idea of running the same application across multiple OpenSocial containers is possible, but it is not as simple as documented.

OpenSocial provides various libraries to support a variety of applications and technologies (LeBlanc, 2011a). For instance, it provides a .NET client library, which enables the communication with the RESTful APIs of the OpenSocial container using Microsoft .NET based technologies (e.g. Kinect-based applications). OpenSocial offers a so-called external interface mechanism that allows developers to use OpenSocial functionality from other web scripting languages, e.g. Flash ActionScript, through a mapping to the OpenSocial JavaScript API. As mentioned, it is possible to develop advanced applications that typically rely on a database. For example, patient parameters (e.g. weight) can be stored in a database with the data acquisition date, and plotted using JavaScript and Google chart.
APIs. However, in our experience, the development of novel server-side applications can be time consuming due to the lack of suitable tutorials and documentation.

The OpenSocial specification does not say anything about data sharing (e.g. patient parameters) between two gadget applications. Since OpenSocial is a specification, it can be extended accordingly, i.e. we can write our own APIs to extend OpenSocial. Depending on the requirements, functionalities can be provided by extending the OpenSocial API or by writing customised modules in Drupal. For instance, the sharing of patient parameters between applications can be achieved by using user profile data from CMS instead of using OpenSocial. When data is stored, it is stored in a platform like HC4L or Facebook. Security is always a primary concern for the container and the applications it is hosting. OpenSocial is part of the container and depends on the services and data of the platform. Therefore, the security aspects need to be implemented first in the platform and then in the applications. Häsel and Iacono (2010) provided an analysis of the built-in security mechanisms that are supported by OpenSocial and shared several recommendations to enhance them.

OpenSocial enables developers to embed non-OpenSocial-based applications into containers. However, if an application such as a hand tracking application requires a special plug-in such as Silverlight, this application will not execute within the OpenSocial container without the plug-in. Therefore, it is necessary to develop a sandbox (testing environment) that enables developers to test their gadget application prior to submitting them to appear in the application directory of a system. Such a sandbox could be used to assure that applications run on the common systems used by HC4L users.

OpenSocial specifies a common standard for sharing social data between two social networks and with OpenSocial applications. Potential developers of HC4L will be able to host their application on various OpenSocial-based containers such as MySpace, Orkut and Hi5, but some of the biggest social networking sites such as Facebook do not support OpenSocial. However, as indicated in Section 5.1.1 on page 56, there are many other reasons for contributing health support applications to an extendable telehealth system such as HC4L.

OpenSocial is a flexible specification that can be treated as a blue print to design large scale enterprise applications, but it mainly focuses on social networking, social media and related entities (LeBlanc, 2011a). If developers are interested in making an enterprise-level software such as a telehealth system, they can define their own API and specification if the needed functionality is not already present in the OpenSocial specification.
7.3.2. Drupal

Drupal reduced the development time for realising our system. Drupal’s modularity and extensibility, i.e., the availability of its contributed modules, made it easier to implement functionalities. These modules can be used directly or modified to implement the desired features. Most of the modules are sufficiently documented to understand the source code and its implementation.

The contributed *Shindig-Integrator* module enables Drupal-based social networking sites to become OpenSocial compliant. However, the *Shindig-Integrator* module is old and rarely updated. It depends on other modules that have been upgraded while the *Shindig-Integrator* was not. Drupal modules can only work with a particular version of Drupal. For instance, a site that uses Drupal 6.0 will not be able to run any modules that are designed for Drupal 7.0 as well as Drupal 5.0. A common issue with Drupal is that popular modules continue to be developed (upgraded to the latest version of Drupal) and less active modules are less frequently upgraded or even abandoned. However, this does not mean that developers should not use a less active module, but they should prepared to invest their time in making the module work for them.

It was challenging to understand the Drupal architecture and *Shindig-Integrator* module code, in order to be able to change it as per HC4L. Furthermore, the *Shindig-Integrator* module only supports Apache Shindig release 1.0.x-incubating, i.e. it does not support OpenSocial 2.0. Therefore, we were not able to integrate the new enterprise and consumer features provided by OpenSocial 2.0. This could only be done when the *Shindig-Integrator* module was upgraded or we invested more time improving it ourselves.

Drupal has evolved as a significant application development tool, but it suffers from several limitations. Firstly, its open-source modules rely on volunteer maintainers, which may or may not be available for non-mainstream modules. The problem of maintenance is not unique to open-source; the same happens for commercial software. The maintenance effort invested depends mostly on how much something is actually used/needed. Another important issue is selecting the right module for a project. Even though Drupal comes with more than 11,000 contributed modules, many of them have similar functionalities. Some modules are easier to use than others, e.g. require the user to write less lines of code to achieve a desired functionality (Buckman, 2011). However, Drupal does not provide any guidelines for selecting the most suitable modules. Users are expected to make their own selection by testing how well a module fits into their project.
7.4 Conclusion

In this chapter, we described the implementation of HC4L and provided an overview of how the third-party applications can be implemented and integrated with our system. We also discussed the challenges in implementing the system. Our implementation demonstrates that the OpenSocial API and the Drupal CMS integrate well and can be used in developing extendable online telehealth systems with social networking functionalities. Although some known minor issues persist (e.g. compatibility and documentation issues), there are many advantages of leveraging these technologies for developing online telehealth solutions. In the following chapter, we present a formative evaluation of HC4L that was aimed at receiving useful feedback from potential users for improving the system.
Figure 7.6.: Screenshot illustrating the *Calorie Calculator* (from LabPixies.com) running within HC4L.
8. Formative Evaluation

Formative evaluations allow developers to reflect on a system prototype and highlight any design faults at an early stage, thereby facilitating the improvement of the system before it is ready for deployment. Typically the evaluation is conducted by involving end-users in the system design process, which is especially important when developing patient-centric systems (Arsand and Demiris, 2008). Hands-on sessions with real users are rewarding and often lead to more spontaneous suggestions for improvements of the system (Newell, 2008). This chapter presents a formative evaluation of a functional prototype of HC4L with a small number of seniors.

Aims of the study are presented in Section 8.1. The study methodology is described in Section 8.2. Section 8.3 presents the results which are discussed in Section 8.4. Excerpts of the results of the evaluation were published in Dhillon et al. (2012c).

8.1. Aims of the Study

The aim of this evaluation is to assess the usability (ease-of-use) and functionality (utility) of HC4L, and based on this improve the system. In particular, we would like to answer the following questions:

1. What are the most significant usability issues experienced by users with HC4L? What are the most common mistakes users are making?
2. What aspects of HC4L work well for the users? What do they find frustrating?
3. What other functionalities users would like to see in HC4L?

8.2. Methodology

Research provides various methods to assess the usability of web-based applications (Nielsen, 1996, Kushniruk et al., 1997, Kushniruk et al., 2000). The methods have different strengths and weaknesses, which need to be taken into account when choosing a
methodology for a user study. For instance, the focus group method is reported to be less effective when dealing with seniors, because it can be difficult to obtain in-depth information and keep the participants “on topic” (Lines and Hone, 2004). Several authors suggest using a multi-method approach (Kushniruk et al., 2001, Arsand and Demiris, 2008, Bozkurt et al., 2011) to gain a deeper understanding of the intended system as well as to offset the weaknesses of any one method with the strengths of another. Hence, we employed individual walkthrough, the think aloud protocol, the question asking protocol, and structured questionnaires and interviews.

The popular heuristic evaluation founded by Nielsen (1994) was also administered in this study. Often, this evaluation methodology is conducted in collaboration with experts (or those with experience). Since our focus was on the usability aspect of the system with regard to seniors that are often perceived to face challenges when dealing with technology, we involved representatives of potential users of HC4L as evaluators. The aim was to evaluate the system usability through the eyes of the potential users instead of experts. This methodology was inspired by other usability studies, e.g. Bozkurt et al. (2011), that have used this heuristic approach and most importantly involved end users as the evaluators of their intervention.

8.2.1. Procedure

Individual evaluation sessions (lasting approximately 90 minutes) were conducted in participants’ homes between January and February 2012. Participants were recruited by posting advertisements in senior community centres, clubs and retirement homes. Participants had to be aged 65 and above and had to be able to use a web browser.

Prior to the usability testing, an overview of HC4L and its specific aims were presented. Participants then provided demographic data and information on their background and computer experience. The demographic and evaluation questions are provided in Appendix D.2 on page 167. In the first part of the evaluation, participants were required to perform a series of tasks with HC4L with minimum assistance. Instructions were presented textually on a piece of paper. Table 8.3 on page 113 shows the task list, which is grouped into two parts: social networking features and health applications. The task list included simple tasks such as signing up and logging out of the system. These tasks may seem trivial, but helped in identifying any difficulty faced by the user in locating the intended buttons. The health applications section consisted of interaction with the two applications hosted in HC4L. Simple steps such as editing previously entered weight values in the Weight Tracker were included to ensure the user was able to use the application.
8.2 Methodology

intuitively, i.e. without having to consciously stop and figure the user interface out.

Participants were encouraged to think-aloud, and to verbalise their thoughts, feelings, and opinions while interacting with the system. This technique helped to better understand participants’ thoughts and emotions while working with the system. Participants’ verbatim comments and interactions with the system were recorded and analysed to identify design issues and potential areas for improvement. After each session, the video and audio recordings were transcribed to text and coded for data analysis. The question-asking protocol was used to complement the think-aloud method by asking direct questions about the system. For example, “How would you set your goal weight in the weight tracker application?” This method proved useful as it revealed participants’ thought-processes as to how they perceived the system, and the problems they encountered in understanding and using the system.

Upon completing the task list, participants were requested to complete a post-test questionnaire. In addition, a short interview was conducted with each participant to gain further insight into their general perceptions about HC4L. Participants were presented with several semi-structured questions, including what they liked best and least about HC4L, and other features they would like to see in the system.

8.2.2. Instrumentation

The evaluation questionnaire consisted of three sections: functionality, usability and user interface. For the first section, participants were presented with 11 cards listing functionalities of HC4L which had to be ranked in order of importance.

The SUS (System Usability Scale), a well-known previously validated scale, was used to assess the overall usability of the system. SUS is a simple scale comprising 10 items rated on a five-point Likert scale from strongly disagree (1) to strongly agree (5), that provides a global view of usability (Brooke, 1996). Table 8.1 lists the 10 items of SUS. Participants’ responses to the statements were calculated as a single score, ranging from 0 to 100, with a higher score indicating a better usability. An individual SUS score will be interpreted using an adjective rating that correlates with the score (Bangor et al., 2009). Figure 8.1 illustrates a comparison between a SUS score and the correlated adjective rating.

In the third section of the questionnaire, 11 Likert-type statements related to the user interface of HC4L were presented. These statements were carefully designed by ourselves, i.e. we did not use existing scales since we wanted to included questions that are specific to the user interface of HC4L (see Table 8.6 on page 116).
Table 8.1.: The 10 items of SUS (adapted from Brooke, 1996).

<table>
<thead>
<tr>
<th>No.</th>
<th>Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I think that I would like to use this system frequently.</td>
</tr>
<tr>
<td>2</td>
<td>I found the system unnecessarily complex.</td>
</tr>
<tr>
<td>3</td>
<td>I thought the system was easy to use.</td>
</tr>
<tr>
<td>4</td>
<td>I think that I would need the support of a technical person to be able to use this system.</td>
</tr>
<tr>
<td>5</td>
<td>I found the various functions in this system were well integrated.</td>
</tr>
<tr>
<td>6</td>
<td>I thought there was too much inconsistency in this system.</td>
</tr>
<tr>
<td>7</td>
<td>I would imagine that most people would learn to use this system very quickly.</td>
</tr>
<tr>
<td>8</td>
<td>I found the system very cumbersome to use.</td>
</tr>
<tr>
<td>9</td>
<td>I felt very confident using the system.</td>
</tr>
<tr>
<td>10</td>
<td>I needed to learn a lot of things before I could get going with this system.</td>
</tr>
</tbody>
</table>

Figure 8.1.: A comparison of the adjective ratings, acceptability scores, and school grading scales, in relation to the average SUS score (from Bangor et al., 2009).

8.2.3. Analysis

Task success was used to measure participants’ ability to perform the test tasks. A participant’s task performance was rated as follows: 0 - fails to complete the task and 1 - succeeds in completing the task. Task completion time was not measured since the think-aloud protocol is known to impact that measurement (Sauro, 2010). Video session recordings were carefully analysed to take note of participants’ success rate in completing the tasks.

The verbatim comments and interviews were evaluated using qualitative content analysis (Elo and Kyngäs, 2008). The frequency of a particular statement or similar statements was counted, and comments with the highest frequency were identified as important. Illustrative quotes were also highlighted. Usability problems identified via the coded text data were grouped according to Nielsen’s 10 usability heuristics (Nielsen, 1994) with their frequencies noted.

The overall usability scores were calculated with the methodology of the SUS described
8.3 Results

8.3.1. Participant Characteristics

The study participants were eight senior volunteers (three males and five females) between the ages of 67 and 90 (mean age 77, SD = 7.78) which fulfilled the criteria for the usability study, i.e. they had basic computer skills and were selected based on the fact that they represent the intended users of HC4L. See Table 8.2 on the current page for other baseline characteristics of the sample. The profile of the individual participants is available at Appendix D.1 on page 167.

Table 8.2.: Demographic characteristics of the formative evaluation participants.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>n</th>
<th>%</th>
<th>Characteristic</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td>Uses Facebook</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>5</td>
<td>62.5</td>
<td>Yes</td>
<td>6</td>
<td>75</td>
</tr>
<tr>
<td>Male</td>
<td>3</td>
<td>37.5</td>
<td>No</td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
<td>Uses a Self-care tool</td>
<td></td>
<td></td>
</tr>
<tr>
<td>European</td>
<td>6</td>
<td>75</td>
<td>No</td>
<td>6</td>
<td>75</td>
</tr>
<tr>
<td>Indian</td>
<td>1</td>
<td>12.5</td>
<td>Yes</td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>Asian</td>
<td>1</td>
<td>12.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer Usage</td>
<td></td>
<td></td>
<td>Living Circumstances</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5+ days/week</td>
<td>6</td>
<td>75</td>
<td>Spouse/partner</td>
<td>7</td>
<td>87.5</td>
</tr>
<tr>
<td>1-4 days/week</td>
<td>2</td>
<td>25</td>
<td>Alone</td>
<td>1</td>
<td>12.5</td>
</tr>
</tbody>
</table>

8.3.2. Completion of Task List

Table 8.3 on page 113 shows the number and percentage of participants completing each test task successfully. In the following, we describe some of the most important observations.

Six participants (75%) were not able to change their password in HC4L (Part 1: Task 9). The link to change the password was provided in the Settings page, which was made accessible via the Settings button located at the top right corner of the system (see Figure 8.2). However, most of the participants ended up searching for this feature in the
Profile page. Some users referred to the Help for guidance. It was apparent that they were expecting all features or pages to be accessible via the icon-based horizontal menu.

Four participants (50%) were not able to locate and add registered members of HC4L as friends (Part 1: Task 3). Although the Search icon was provided in the icon-based horizontal menu (see Figure 8.2), the participants were looking for this functionality on the Friends page.

The participants did not face any serious problems in completing Part 2 of the task list. However, one participant was not able to login after logging out of the system. He had forgotten his password and was not able to retrieve it. This frustrated him as he had to sign up with the system again to be able to continue with the rest of the tasks.

Figure 8.2.: Location of the Settings and Search buttons in HC4L at the time of evaluation. The Activities screen was termed as My Home and the Health Apps was captioned as Apps.
8.3 Results

Table 8.3: Task list and success rates number (and percentage) of participants who have successfully completed the task.

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Successful n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Part 1 - Social Networking Features</strong></td>
<td></td>
</tr>
<tr>
<td>1. Sign Up with HC4L.</td>
<td>7 (87.5)</td>
</tr>
<tr>
<td>2. Complete your profile.</td>
<td>8 (100)</td>
</tr>
<tr>
<td>3. Search for Sanggita and add her as a friend.</td>
<td>4 (50)</td>
</tr>
<tr>
<td>4. Accept Jaspal as a friend.</td>
<td>8 (100)</td>
</tr>
<tr>
<td>5. Send a mail to Sanggita.</td>
<td>8 (100)</td>
</tr>
<tr>
<td>6. From ‘My Home’, share a message with all your friends in HC4L.</td>
<td>8 (100)</td>
</tr>
<tr>
<td>7. Comment on Jaspal’s message.</td>
<td>8 (100)</td>
</tr>
<tr>
<td>8. Remove Sanggita from your friends list.</td>
<td>7 (87.5)</td>
</tr>
<tr>
<td>9. Change your password.</td>
<td>2 (25)</td>
</tr>
<tr>
<td>10. Invite Sam to join HC4L.</td>
<td>6 (75)</td>
</tr>
<tr>
<td>11. Logout from HC4L.</td>
<td>8 (100)</td>
</tr>
<tr>
<td><strong>Part 2 - Health Applications</strong></td>
<td></td>
</tr>
<tr>
<td>1. Log into the system.</td>
<td>7 (87.5)</td>
</tr>
<tr>
<td>2. Find and add the following applications to your application page:</td>
<td>8 (100)</td>
</tr>
<tr>
<td>(1) Weight Tracker and (2) Multiplayer Memory Game.</td>
<td></td>
</tr>
<tr>
<td>3. Enter your estimated weight.</td>
<td>6 (75)</td>
</tr>
<tr>
<td>4. View your weight graph.</td>
<td>8 (100)</td>
</tr>
<tr>
<td>5. Assuming that you entered the wrong value, edit the weight value</td>
<td>6 (75)</td>
</tr>
<tr>
<td>you just entered.</td>
<td></td>
</tr>
<tr>
<td>6. Enter your goal weight.</td>
<td>7 (87.5)</td>
</tr>
<tr>
<td>7. Play the memory game with Jaspal until all image pairs are</td>
<td>7 (87.5)</td>
</tr>
<tr>
<td>uncovered.</td>
<td></td>
</tr>
<tr>
<td>8. Rate the applications (using a five-star scale).</td>
<td>8 (100)</td>
</tr>
<tr>
<td>9. Delete your user account.</td>
<td>8 (100)</td>
</tr>
</tbody>
</table>

8.3.3. Card Sorting

Table 8.4 on the following page depicts the main features of HC4L in descending order of importance as perceived by participants. Participants were mainly interested in having access to health-related applications and viewing their health progress with easy to understand visuals such as graphs or charts.

The ability to track the total amount of physical and mental exercises performed, although not included in the prototype, seems to be an important feature to participants.
Table 8.4.: Functionalities ordered by importance to the participants.

<table>
<thead>
<tr>
<th>Functionalities</th>
<th>Mean Rank*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access to health-related applications</td>
<td>2.1</td>
</tr>
<tr>
<td>View health data using graphs/charts</td>
<td>3.3</td>
</tr>
<tr>
<td>Track the total amount of physical and mental exercise</td>
<td>4.3</td>
</tr>
<tr>
<td>Send a message to a friend</td>
<td>4.9</td>
</tr>
<tr>
<td>Play social games with friends</td>
<td>5.5</td>
</tr>
<tr>
<td>Add and remove applications</td>
<td>6.5</td>
</tr>
<tr>
<td>Search for friends and invite others to join HC4L</td>
<td>6.8</td>
</tr>
<tr>
<td>Add and remove friends</td>
<td>7.5</td>
</tr>
<tr>
<td>Keep caregiver/family member informed about activities in the system</td>
<td>7.8</td>
</tr>
<tr>
<td>Perform/view application ratings</td>
<td>8.6</td>
</tr>
<tr>
<td>Facebook-like comment feature</td>
<td>8.9</td>
</tr>
</tbody>
</table>

*A low mean value means more important

Interestingly, participants did not enjoy having a Facebook-like comment feature. Participants got distracted with the What’s on your mind? text box on the My Home screen of the system. Although the majority of participants had used Facebook before and were familiar with this message sharing feature, they were not sure what to share with their friends in the HC4L network. They could share anything but most participants thought they had to share something related to their health. In other words, most of the participants felt that they should only talk about health, since HC4L is a healthcare application.

Users can rate an application by using a five star rating, but the ability to perform and view application ratings does not seem to be important to them. We observed that participants were more interested in an application’s description than its average star rating when deciding which application to add to their profile. Keeping a family member or caregiver informed about their activity is also regarded as non-essential as the majority of the participants (87.5%) were living with their spouses or families. However, most participants commented that this feature would be very useful to seniors who are disabled or living alone.

8.3.4. System Usability Score

Participants rated the usability of the system positively. SUS scores obtained from participants’ responses are presented in Table 8.5. The scores range between 65 and 97.5, with a median of 71.25. The average SUS score is 75, which means that the overall usability is rated as “Good”.

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8.3 Results

**Table 8.5:** Individual SUS scores and corresponding adjective ratings of the participants.

<table>
<thead>
<tr>
<th>Participant No.</th>
<th>SUS Score</th>
<th>Adjective Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>65</td>
<td>OK</td>
</tr>
<tr>
<td>2</td>
<td>70</td>
<td>Good</td>
</tr>
<tr>
<td>3</td>
<td>65</td>
<td>OK</td>
</tr>
<tr>
<td>4</td>
<td>70</td>
<td>Good</td>
</tr>
<tr>
<td>5</td>
<td>85</td>
<td>Excellent</td>
</tr>
<tr>
<td>6</td>
<td>75</td>
<td>Good</td>
</tr>
<tr>
<td>7</td>
<td>72.5</td>
<td>Good</td>
</tr>
<tr>
<td>8</td>
<td>97.5</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

8.3.5. User Interface

Results from the questions related to the user interface of HC4L are shown in Table 8.6 on the next page. The results indicate that the participants are generally very satisfied with the user interface of the system. This could be due to the fact that HC4L is presented with a simple icon-based horizontal menu at the top which helps users in identifying the key functionalities of the system. Results show that this is a good design, as it is intuitive to users, especially to novices.

The menu items (and buttons) contain graphics and text to enable users to rapidly understand their meaning and locate them easily (see Figure 8.2 on page 112). For instance, an envelope icon is used to represent the mail function. However, one participant felt the icon and terminology used for the Facebook-like comment page, i.e., *My Home*, was misleading. Two other participants thought that the *Profile* icon was not suitable for a system targeting seniors, as it depicts a much younger person.

In terms of colour, the interface of HC4L uses different shades of green for the top banner, main menu and footer. The colourful icons were designed to aid users to visually identify them easily. The main content area (excluding the health applications) is maintained white throughout the system to enable users to focus on the content and read it easily.

8.3.6. Usability Problems

An examination of the user responses from the think aloud session uncovered a range of usability problems, which we classified according to 10 heuristics. A listing of the problems, together with the number of users experiencing them, is shown in Table 8.7 on page 118.
Table 8.6: Evaluation of the user interface. The table shows for each statement regarding the user interface, the number of participants for each level of agreement, average response and midpoint comparison.

<table>
<thead>
<tr>
<th>No.</th>
<th>Question</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>Mean</th>
<th>p-value</th>
<th>% Agree*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>The horizontal menu appearing at the top makes it easy to identify the key functionalities of the system.</td>
<td>0</td>
<td>3</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>87.5</td>
</tr>
<tr>
<td>2.</td>
<td>The information on the site is organized.</td>
<td>0</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>87.5</td>
</tr>
<tr>
<td>3.</td>
<td>The icons helped in finding things in the site faster.</td>
<td>3</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>4.</td>
<td>It is easy to navigate through the site.</td>
<td>0</td>
<td>7</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>87.5</td>
</tr>
<tr>
<td>5.</td>
<td>The graphics on this website are visually pleasing.</td>
<td>1</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>6.</td>
<td>The font is easy to read.</td>
<td>0</td>
<td>9</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>7.</td>
<td>The text on the website is easy to read.</td>
<td>0</td>
<td>9</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>8.</td>
<td>The links and buttons in the website do what I expect them to do.</td>
<td>0</td>
<td>2</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>9.</td>
<td>The used icons represent the corresponding functions well.</td>
<td>1</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>87.5</td>
</tr>
<tr>
<td>10.</td>
<td>I feel lost when using this website.</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>11.</td>
<td>The text on the website is easy to understand.</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>6</td>
<td>1</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

*Percent Agree (%) = Agree & Strongly Agree Responses combined
The table shows that each heuristic was violated at least one time. Most usability problems were grouped under the *User control and freedom* heuristic and had a total of 12 occurrences. This was followed by problems related to *Match between system and the real world*, with 8 occurrences. From the 20 identified problems, *Not able to locate the changing password page* (75%), *Incomplete/misleading labels* (62.5%) and *No information about what is username* (62.5%) were the most frequently named issues.

The user interface was modified and the identified shortcomings were remedied. The *Settings* button, which directs users to a list of all the necessary pages (e.g. link to the page to change password), was made part of the main menu. The identified incomplete or misleading labels were changed as suggested by the participants. For instance, the label *Email of Caregiver* in the *Profile* page was changed to *Email of Family member/Caregiver*. Since most participants faced problems in understanding the term *username*, description of this term (with an example) was provided next to the username text box at the sign up page.

### 8.3.7. Interviews

Participants provided feedback about what they liked most and least about HC4L, and gave recommendations for improving the system. Table 8.8 lists the questions asked during the interview, along with responses and their frequencies.

Results from the interview show that most participants liked the simplicity of the system and the personal weight graph. In contrast, they were not keen on the Facebook-like commenting feature. There were suggestions to include more medical and health-related applications. Applications generally should promote exercises and enable users to manage their diet. There were specific requests to include applications supported by easy-to-understand graphs enabling users to track their blood sugar level and BP. Apart from having more health applications, there were strong recommendations to make the *Settings* button accessible via the icon-based horizontal menu.

### 8.4. Discussion

The main aim of the study was to assess the usability and user interface of HC4L in order to improve the final version of the prototype. We also wanted to determine the function-
### Classification and frequency of usability problems.

<table>
<thead>
<tr>
<th>Heuristic Violated</th>
<th>Problem Description</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visibility of system status</td>
<td>No confirmation that an application was added successfully</td>
<td>2/8</td>
</tr>
<tr>
<td></td>
<td>No indication that the memory game was loading</td>
<td>1/8</td>
</tr>
<tr>
<td>Match between system and the real world</td>
<td>The country list box not listed alphabetically</td>
<td>2/8</td>
</tr>
<tr>
<td>User control and freedom</td>
<td>Slow load time</td>
<td>1/4</td>
</tr>
<tr>
<td>Consistency and standards</td>
<td>Unexpected errors (codes)</td>
<td>3/8</td>
</tr>
<tr>
<td>Error prevention</td>
<td>Unnoticed validation messages</td>
<td>1/8</td>
</tr>
<tr>
<td>Recognize rather than recall</td>
<td>Unable to retrieve password</td>
<td>1/8</td>
</tr>
<tr>
<td></td>
<td>Unselected categories (codes)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Misleading/unnecessary back button in the application directory pane</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Not able to locate the adding friends page</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Not able to locate the changing password page</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Show load time</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Use control and freedom</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nothing message box in memory game</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Incomplete/inaccurate labels</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The country box not needed alphabetanny</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Meck between system and the real world</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No indication that the memory game was loading</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No confirmation that an application was added successfully</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No information about what is username</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No information about number of characters expected for password</td>
<td></td>
</tr>
<tr>
<td>Help and documentation</td>
<td>Help users recognize, diagnose, and recover from errors</td>
<td></td>
</tr>
<tr>
<td>Usable and minimally designed</td>
<td>Unneeded mechanism when accepting one as friend</td>
<td></td>
</tr>
<tr>
<td>Flexibility and efficiency of use</td>
<td>Desire to have the settings button be part of the main menu</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unneeded Facebook-like comments</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unnecessary message box when accepting one as friend</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Complete weight in weight tracker application to be based on BMI</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Incomplete/misleading labels</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Misleading message box in memory game</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Incomplete/inaccurate labels</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Use control and freedom</td>
<td></td>
</tr>
</tbody>
</table>

**Note:**

- The table above represents the classification and frequency of usability problems in the context of Chapter 8: Formative Evaluation. Each entry details the heuristic violated, the problem description, and the frequency with which it occurred. The table includes specific examples, such as issues related to visibility, match between system and the real world, user control and freedom, and help and documentation, among others. The frequency is indicated by the number of occurrences, with a denominator of 8 to indicate the sample size for each category.
Table 8.8.: Interview questions, responses, and number of participants with that response.

<table>
<thead>
<tr>
<th>Questions</th>
<th>Responses</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>What are the things you liked best about HC4L?</td>
<td>- Simplicity</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>- Focus on health and growing older</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>- Weight graph</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>- User friendly</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>- Memory game</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>- Social contact</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>- More useful than Facebook</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>- Colourful initial page</td>
<td>1</td>
</tr>
<tr>
<td>What are the things you liked least about HC4L?</td>
<td>- Facebook-like comments</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>- Time consuming on computer</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>- Sending messages to friends</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>- Slowness to surf across screens</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>- The use of the word “elderly”, instead of “senior”</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>- Picture on homepage</td>
<td>1</td>
</tr>
<tr>
<td>What other functionalities you would like to see in HC4L?</td>
<td>- More health applications (reminders, diet, exercise, vitals)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>- Add settings button as one of the main buttons</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>- Compare health problems</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>- Add Sudoku and Crosswords</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>- Show who is online</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>- Health information e.g. desired heart rate for age</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>- Links to health sites (e.g. MedPlus (NIH))</td>
<td>1</td>
</tr>
</tbody>
</table>

alities most and least important to potential users. This information and personal recommendations from the participants helped to confirm the user requirements for HC4L.

Although the study had a low number of participants, research suggests that conducting usability testing with as few as five users can reveal 85% of the usability problems of a system or website designed for a target user group (Nielsen and Landauer, 1993, Nielsen, 2000). Furthermore, eight to ten participants are sufficient to identify and summarise the majority of usability problems and issues related to a health information system (Kushniruk et al., 1997).

Results from the card sorting activity and interviews strongly indicate that seniors want to see more health-related applications in the system. Access to a wide variety of health applications is a major motivation for patients to use HC4L. Furthermore, the available applications must meet unique needs of patients. Hence, a web-based telehealth system
should be designed with an open architecture, enabling developers to contribute content. Based on our observations, most of the participants were keen on using both sample applications in the system, i.e., the Weight Tracker and the Multiplayer Memory Game, which were designed to be self-explanatory and easy-to-use for seniors.

The high SUS score of HC4L indicates that the Web is a suitable medium to deliver telehealth solutions to seniors with some web browsing experience. Based on our observations and the interview results, it was apparent that participants liked the idea of using a web-based telehealth system to manage their healthcare. The idea of involving family and friends in their healthcare was very well received. Participants were positive about the potential of the system, especially the attempt to tackle social isolation, which is a serious concern among seniors living independently. Study participants were aware that web-based telehealth solutions are complementary interventions and not meant to substitute primary care.

There is strong indication that imitating the Facebook-like comment feature does not work for healthcare systems. The What’s on your mind? feature was included in HC4L as a means to foster interaction among participants. Such a feature is quite successful in Facebook and we wanted to see if a simplified and bigger version of the same would work in HC4L. In fact, the Facebook-like comment feature has become a standard mechanism to encourage communication among users and is widely used in other popular sites such as Google+, Skype and social diet websites, e.g. MyFitnessPal.com (see Figure 4.2 on page 49). The seniors also did not like to receive updates such as who is a new friend of their friend in the system. Health-related systems are generally seen as more serious applications by users. Therefore, any commenting feature should serve a clear purpose, such as to enable patients to encourage each other in managing their own health. For instance, patients might feel more encouraged and motivated if they can share their scores with friends in the network. Sharing performance might create a competitive spirit between users and might result in users receiving encouraging comments from their friends. This idea was suggested to the participants during the interview session and was well received by them.

One of the participants (FP7) made an important statement concerning the use of a computer for personal healthcare: “Web-based telehealth system could be time consuming, needing us to spend too much time on the computer and that’s not good. We need to be active and should be doing exercise. The system should promote exercise.” Therefore, it is crucial to focus on applications that promote exercise and physical activity. Consumer-level motion sensing devices such as iPhones, Wiimotes and Kinect can be leveraged for
improving users’ healthcare by delivering innovative and effective exercise-based health applications. A telehealth platform should ideally be ubiquitous and do not physically constrain users to a computer.

It was apparent that seniors want easy access to all the functionalities provided in the system. If users want to change certain settings (e.g., change a password or to make changes to privacy settings), then it must be easy to find. As mentioned, most participants were not able to locate the button to change their passwords. The Settings button provided at the top right corner of the screen (see location of the button at Figure 8.2 on page 112) was overlooked and users were searching for it within the icon-based horizontal menu. In order to encourage use, any such setting must be easy to find and update. We found it advantageous to have a Settings button that is clearly made visible to users along with core functionalities provided in the system via the main menu.

Based on participants’ comments and our observations, it was clear that seniors generally expect immediate feedback for every little action they do in a system. They are generally more concerned, suspicious and careful about their interactions with a computer and expect clear guidance. Hence, the system should provide informative feedback (modest or substantial depending on the expected action by the user), which in fact is a well-known principle of good interaction design suggested by Shneiderman and Plaisant (2010). For instance, after adding an application from the application directory, they prefer to see a confirmation message indicating that they have added the intended application successfully. Such messages keep them informed and in control.

From the video analysis, it was clear that when participants were not able to do a particular task, they immediately look for help in the system. This emphasises the need of a carefully designed help functionality in the system. Two participants suggested that the help feature could be in the form of an FAQ (Frequently Asked Questions). Video tutorials were thought to be useful for non-standard and more complex features in the system (e.g., the health applications). However, written instructions are preferred over video tutorials, especially to aid seniors with hearing impairments.

Similar to other web-based health systems, HC4L uses patients’ username to identify them in the system. Most of the participants were unclear about this term, which is the first thing they need to decide when they register with the system. Based on our observation, most participants thought they needed to enter their name. A few of them entered their full name with a space or a dot in between their first and last name. Hence, it is important that the labels used in the registration form are clearly described on the screen.

Some of the terminology used in the prototype raised interesting issues. For instance,
the term “friends” used in HC4L represents people added by patients for a variety of reasons, such as to share health experiences, play social games and to keep in touch with. One participant (FP3) was concerned about the appropriateness of this term for the system and expressed that “a friend is someone whom you can depend on and call to share something”. The term “contacts” was suggested as replacement, since it embraces everybody, including family. Another participant (FP5) thought that the term “friends” is more suitable than “contacts”, due to its familiarity to people after being widely used in Facebook.

8.5. Conclusion

A healthcare system ideally should be evaluated while it is being designed and developed to maximise benefits and minimise risks of deployment in a real setting. In this chapter we described a user evaluation of an initial prototype of HC4L. The results have been encouraging and demonstrate that seniors with basic computers skills are able to successfully use the system. We have identified design issues and seniors’ expectations towards HC4L via a multi-method approach. With the help of this information, we were able to improve the system as described below to ensure that it was ready for an extensive long-term evaluation with a larger sample of users (summative evaluation). The following improvements were implemented:

- The content structure of the HC4L was changed to reflect the mental model of the users. Along with the core features, the Settings button was made accessible to users via the main menu. The Search button was renamed as Member Search and located within the Friends page. Icons used for the main menu was changed to suite older adults and to reflect their purpose better.

- The Facebook-like comment page titled My Home was renamed as Activities. Apart from allowing users to comment on each other’s messages, this page now allows users to receive activity streams of their friends in the system. The main purpose of this page is to enable users to motivate each other by writing positive comments. A thumb-up button is also provided to encourage use of the health applications. Healthcare4Life score, a general score indicating users’ health in the system, was included. See Section 5.3.1.1 on page 66 for more information about the Activities screen and the Healthcare4Life score.
The term username was clearly described next to the input box in the registration form. It was indicated that users are not encouraged to use their real name as their username for privacy purposes. Other necessary information such as the number of characters expected in the password was provided.

Unexpected errors found in the system during the evaluation were fixed. The system now features the ability to receive a forgotten password by email. However, this feature will not address the problem of the user not having an email or not having one specified during the sign up. Furthermore, the system provides immediate feedback for almost every action a user takes in the system (e.g. a confirmation message that a friend request was sent successfully).

Two more health applications (i.e. Vital Tracker and Exercise Tracker) were created and made available to the users via the applications directory. See details about these applications in Section 5.3.2 on page 73. An existing diet application called Calorie Calculator was included in HC4L.

Now that we have fixed most of the usability problems and enhanced the features of HC4L, we are ready to evaluate its feasibility and acceptability by seniors. We will describe the design and the results of the summative evaluation in the following chapter.
9. Summative Evaluation

In the previous chapter, we presented and discussed the formative evaluation of HC4L. Results and feedback received from participants of the study were used to develop an improved version of the application. This chapter presents a summative evaluation of the improved version of HC4L with a larger number of users.

Section 9.1 presents the aims of the study. Section 9.2 describes the methodology used in the evaluation. Section 9.3 presents the results which are discussed in Section 9.4. Results of this evaluation were published in Dhillon et al. (2012e) and Dhillon et al. (2013).

9.1. Aims of the Study

The goals of this evaluation were to test the feasibility and acceptability of a web-based telehealth system with seniors. The secondary objectives were to assess the user satisfaction, effectiveness of the system, and its content. In order to meet the goals, we developed the following specific questions to guide the investigation.

1. Which functionality of HC4L was most and least used by the users? What did the users like and dislike about HC4L?

2. How do the users rate the overall usability of HC4L?

3. Can HC4L affect the attitude of users towards their health management?

4. How motivated are the users to leverage HC4L for their health?

9.2. Methodology

9.2.1. Procedure

The study used a mixed method approach. HC4L was made accessible via the Web using the domain Healthcare4Life.com. A six-week live user evaluation on the HC4L system
was carried out from June to August 2012. Participants were recruited by posting advertisements in senior community centres, clubs and retirement homes in New Zealand. Participants were expected to be aged 60 and above. Prior knowledge or experience with computers was not required. We also contacted several learning centres of SeniorNet\(^1\) (SeniorNet.co.nz) and Wellington ICT\(^2\) (WellingtonICT.org.nz) to advertise the study to eligible members. In order to avoid distortion of results due to prior experience (McLellan et al., 2012), participants of the formative evaluation of the system were not involved in the study.

The study was conducted at two SeniorNet learning centres in Auckland (SeniorNet Eden-Roskill and SeniorNet HBC) and in a council housing computer hub operated by Wellington ICT in Wellington. The study began with a one-hour session comprising a system demonstration and basic explanations of how to use the system, which was offered on several days at the facilities. The objective was to provide an overview of HC4L, the user study, what was expected from the participants, and to create user accounts to access HC4L. As suggested in our taxonomy of usability requirements for telehealth systems (presented in Section 3.2.2 on page 33), a printed user guide (available at Appendix F on page 187) containing step-by-step instructions to use basic features of HC4L was provided. Details of the user study and a softcopy of the user guide were made accessible via the HC4L homepage. A brief list of activities users can do in the system (see Table 9.1 on the facing page) was included.

Participants were encouraged to use the system at their own pace over a six week period and activities in the system were logged for later analysis. In order to maintain confidentiality and anonymity, participants were advised to avoid using their real name or part of their real name as their username in the system. Reminders to use HC4L were provided via email once every week.

Participants had to complete three online questionnaires at different stages of the study: after the initial meeting (initial questionnaire); at the end of the third week (interim questionnaire); and at the end of the sixth week (final questionnaire). The content of the questionnaires with the number of participants that have completed them are provided in Table 9.2 on the next page. At the end of the study, a short interview was conducted with four selected participants (i.e. two from those that were actively using the system and two from those who did not use system) to gain further insights into their experience with and perceptions of HC4L. A NZ$ 40 supermarket voucher was given as a token of appreci-

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\(^1\)A non-profit organisation established to provide computer and technology skills to people aged 50+.

\(^2\)A non-profit trust that offers ICT programmes to communities and community organisations in the Wellington region.
Table 9.1: List of activities the participants could do with HC4L during the evaluation period.

<table>
<thead>
<tr>
<th>No.</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Track your exercise using the <em>Exercise Tracker</em>.</td>
</tr>
<tr>
<td>2.</td>
<td>Track your vital signs using the <em>Vitals Tracker</em>.</td>
</tr>
<tr>
<td>3.</td>
<td>Track your weight using the <em>Weight Tracker</em>.</td>
</tr>
<tr>
<td>4.</td>
<td>Play the <em>Multiplayer Memory Game</em> with another player.</td>
</tr>
<tr>
<td>5.</td>
<td>Use the <em>Healthcare4Life score</em> to motivate yourself to use the applications.</td>
</tr>
<tr>
<td>6.</td>
<td>Increase your social network by adding more friends in HC4L.</td>
</tr>
<tr>
<td>7.</td>
<td>Invite your friends in real life to join HC4L.</td>
</tr>
<tr>
<td>8.</td>
<td>Share messages with your HC4L friends.</td>
</tr>
<tr>
<td>9.</td>
<td>Write comments on your friends’ updates that you receive in the system.</td>
</tr>
<tr>
<td>10.</td>
<td>Use the thumb-up button to encourage your friends to continue using the health applications.</td>
</tr>
<tr>
<td>11.</td>
<td>Send mail or messages to your friends.</td>
</tr>
<tr>
<td>12.</td>
<td>Update your profile.</td>
</tr>
</tbody>
</table>

Table 9.2: Content of the summative evaluation questionnaires and the number of participants who completed them.

<table>
<thead>
<tr>
<th>Survey No.</th>
<th>Assessment Milestone</th>
<th>Content of Questionnaire</th>
<th>Completed (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Initial Meeting</td>
<td>Demographics and MHLC</td>
<td>43</td>
</tr>
<tr>
<td>2</td>
<td>End of Week 3</td>
<td>MHLC, IMI and SUS</td>
<td>24</td>
</tr>
<tr>
<td>3</td>
<td>End of Week 6</td>
<td>Additional Likert scale and open-ended items</td>
<td>21</td>
</tr>
</tbody>
</table>

MHLC = Multidimensional Health Locus of Control  
IMI = Intrinsic Motivation Inventory  
SUS = System Usability Scale

9.2.2. Instrumentation

The questionnaires (see Appendix E.2 on page 176) mostly incorporated existing established scales as explained below: MHLC (Multidimensional Health Locus of Control), IMI (Intrinsic Motivation Inventory) and SUS (System Usability Scale). In order to keep
the questionnaire simple for seniors, shortened forms of these scales were used. Other items contained in the questionnaire recorded information on the participants’ demographics and specific aspects about HC4L. The following scales were used to measure user responses:

MHLC is a scale developed to assess users’ perception whether health is controlled by internal or external factors (Wallston et al., 1978). This scale was employed to investigate whether HC4L can positively affect the users’ attitude towards managing their health, i.e. to make them realise that health is not just controlled by external forces. It was anticipated that the short duration of the study would not be sufficient to gauge behavioural change of seniors towards their health management. Therefore, we have examined the results as a signal of possible future behavioural change (Torning and Oinas-Kukkonen, 2009).

The MHLC scale comprises three subscales: “internal”, “powerful others” and “chance” and has 18 items (six items for each subscale). Following previous studies (Bennett et al., 1994, Baghaei et al., 2011), a shortened version of the scale was used, where nine items (three items for each subscale) were chosen from the original MHLC with six response choices, ranging from strongly disagree (1) to strongly agree (6) (see Table 9.3 on the next page). According to Wallston et al. (1989), the shortened version of MHLC retained adequate internal consistency and test-retest reliability. The score of each MHLC subscale was calculated by adding the score contributions for each of the three items on the subscale. Each subscale is treated as an independent factor - the composite MHLC score provides no meaning. Summed scores for each subscale range from 3 to 18 with higher scores indicating higher agreement that internal factors or external factors (“chance”, “powerful others”) determine health. In order to detect attitudinal changes, participants had to complete the MHLC scale twice: before the evaluation (in the initial questionnaire) and at the end of the third week of the study (in the interim questionnaire). After 3 weeks, the participants would have had the opportunity to become involved with the system. Hence, MHLC was repeated at the end of week 3, while the participants were actively using the system. The intention was to gauge the participants’ attitude while they were well engaged in the study.

The IMI is a measurement tool developed to determine an individual’s levels of intrinsic motivation for a target activity (Ryan, 1982). The scale was adapted to evaluate participants’ subjective experience in their interaction with HC4L. In particular, the scale was employed to assess interest/enjoyment, perceived competence, effort, value/usefulness, and felt pressure/tension while using the system.

Several versions of the IMI scale are available for use. The complete version comprises
Table 9.3.: Subscales of MHLC and respective items (adapted from Wallston et al., 1978).

<table>
<thead>
<tr>
<th>Subscale</th>
<th>Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal</td>
<td>- If I take care of myself, I can avoid illness.</td>
</tr>
<tr>
<td></td>
<td>- If I take the right actions, I can stay healthy.</td>
</tr>
<tr>
<td></td>
<td>- The main thing which affects my health is what I do myself.</td>
</tr>
<tr>
<td>Powerful Others</td>
<td>- Having regular contact with my doctor is the best way for me to</td>
</tr>
<tr>
<td></td>
<td>avoid illness.</td>
</tr>
<tr>
<td></td>
<td>- Whenever I don’t feel well, I should consult a medically trained</td>
</tr>
<tr>
<td></td>
<td>professional.</td>
</tr>
<tr>
<td></td>
<td>- Health professionals control my health.</td>
</tr>
<tr>
<td>Chance</td>
<td>- No matter what I do, if I am going to get sick, I will get sick.</td>
</tr>
<tr>
<td></td>
<td>- My good health is largely a matter of good fortune.</td>
</tr>
<tr>
<td></td>
<td>- If it’s meant to be, I will stay healthy.</td>
</tr>
</tbody>
</table>

seven subscales with 45 items, scored on a Likert-scale from strongly disagree (1) to strongly agree (7). The shortened version of IMI is known to be reliable as well (SDT, n.d.). We used a shortened version using 15 items (three items for each of the five pre-selected subscales), which were randomly distributed in the questionnaire (see Table 9.4 on the following page).

Items of the IMI scale as cited by McAuley and Duncan (1989) can be modified slightly to fit specific activities without affecting its reliability or validity. Therefore, an item such as “I would describe this activity as very interesting” was changed to “I would describe the system as very interesting”. To score IMI, firstly, the contribution score for items ending with an ‘R’ is subtracted from eight, the result is used as the item score. Then, the subscale scores (i.e. the results) are calculated by averaging across the items of the respective subscale.

User satisfaction with the system, similar to the formative evaluation discussed in Chapter 8, was measured using the SUS. A brief overview of SUS is provided in Section 8.2.2 on page 109.

We have included additional Likert-type statements in the final survey (see Table 9.10 on page 136), which were analysed quantitatively. We show whether the responses to these statements were significantly above mid-point by using a one-sample t-test. These questions were not decided upon before the evaluation, but were formulated during the study based on the feedback we received from the participants. The objectives were to obtain participants’ feedback and confirmation on specific concerns related to their experience and future use of HC4L. Several open-ended questions were also added to allow participants to express their opinions about certain aspects of the system.
Table 9.4: Subscales of IMI and respective items (adopted from SDT, n.d.).

<table>
<thead>
<tr>
<th>Subscale</th>
<th>Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest/Enjoyment</td>
<td>- I enjoyed using the system very much.</td>
</tr>
<tr>
<td></td>
<td>- I thought the system was boring. (R)</td>
</tr>
<tr>
<td></td>
<td>- I would describe the system as very interesting.</td>
</tr>
<tr>
<td>Perceived Competence</td>
<td>- I think I am pretty good at using the system.</td>
</tr>
<tr>
<td></td>
<td>- After working with the system for a while, I felt pretty competent.</td>
</tr>
<tr>
<td></td>
<td>- I couldn’t do very well with the system. (R)</td>
</tr>
<tr>
<td>Effort/Importance</td>
<td>- I put a lot of effort into learning how to use the system.</td>
</tr>
<tr>
<td></td>
<td>- It was important to me to learn how to use the system well.</td>
</tr>
<tr>
<td></td>
<td>- I didn’t put much energy into using the system. (R)</td>
</tr>
<tr>
<td>Pressure/Tension</td>
<td>- I did not feel nervous at all while using the system. (R)</td>
</tr>
<tr>
<td></td>
<td>- I felt very tense while using the system.</td>
</tr>
<tr>
<td></td>
<td>- I was anxious while interacting with the system.</td>
</tr>
<tr>
<td>Value/Usefulness</td>
<td>- I think that the system is useful for managing my health from home.</td>
</tr>
<tr>
<td></td>
<td>- I think it is important to use the system because it can help me to become more involved with my healthcare.</td>
</tr>
<tr>
<td></td>
<td>- I would be willing to use the system again because it has some value to me.</td>
</tr>
</tbody>
</table>

9.3. Results

9.3.1. Participant Characteristics

The initial sample consisted of 43 seniors aged 60 to 85 (mean age 70, SD = 17.68). Table 9.5 on the facing page illustrates the baseline characteristics of the participants. Most of the participants were female (62.79%) and European (83.72%). Only 37.21% were living alone, with the rest living with either their spouse/partner or children. The majority of the participants were active computer users (88.37%), using a computer almost every day. Less than half of them (44.19%) used social networking websites such as Facebook. Only 32.56% used self-care tools (e.g. blood pressure cuff, glucometer or health websites). Most of the participants (65.12%) had heard about telehealth. The profile of the individual participants is available at Appendix E.1 on page 175.

9.3.2. System Usage Data

Over the 6 weeks, HC4L was accessed 181 times by 43 participants. The average number of logins per person was 4.21 with SD 4.96 and median 2. It was a challenge to obtain commitment from seniors to engage in the user study over six weeks. As you can see
in Figure 9.1 on the following page, although the study began with a larger sample, the user retention rate dropped over time. This is in fact a common issue in live user studies (Baghaei et al., 2011). Fifteen participants (34.88%) logged in only once and a few of them gave different reasons for not taking part in the study including: they cannot commit that long as they need to look after their unwell spouse; there is not much they can do in the system; and they do not like to involve friends in the system. However, a few participants continued using the system after the sixth week. It is interesting to note that the participant with the highest frequency of usage (25 logins) had very little experience with computers, but was very keen to learn how to use the system well.

Figure 9.2 on the next page depicts the overall usage (i.e. based on the number of times an application/page was loaded) of the six main functionalities provided in the system. The Health Apps feature was most popular (35%) among the participants. The Facebook-like comment page termed Activities was the second-most commonly used feature (22%). This was followed by the Friends page (17%). The Settings page was the least-used functionality (4%). Along with the overall usage of the main functionalities, Figure 9.2 shows the popularity of specific health applications available in the system. The Vital Tracker was the most frequently used application (29%), followed by the Exercise Tracker (28%), and the Weight Tracker (22%). The Calorie Calculator was least used by the participants (8%).
9.3.3. Change in Attitude

Table 9.6 on the facing page reports the mean change scores for those participants who completed both initial and interim MHLC questionnaires. Change scores for each MHLC subscale were calculated by subtracting baseline scores from follow-up scores. A set of paired t-tests was used to compare the two MHLC mean scores (i.e. initial and interim questionnaire) of the sub-scales: Internal, Powerful Others, and Chance. Statistical significance was set to p<0.05 for the statistical analyses.

The findings show that there were some improvements on all the three subscales. There is noticeable difference for participants’ responses for “Powerful Others”, which contained three statements to assess whether health is controlled by others, e.g. health pro-
9.3 Results

professionals. Table 9.7 on the current page shows the difference between participants’ responses before and at the end of Week 3, while they were actively engaged with HC4L. Statement 2 indicates that users rely on healthcare professionals for diagnosis and treatment and HC4L does not make a difference. However, participants’ disagreement with Statement 3 showed significant difference \((P = 0.03, t=2.343)\), which indicates that users have obtained a better understanding of their health and how their own decision effect their health. This suggests that the use of HC4L has the potential to positively change the attitude of users that their health is not controlled by health professionals. The results are significant, but it would be preferable to use a larger sample population, a longer study duration, and redundant questions to confirm the results.

**Table 9.6:** Change in user responses to the MHLC subscales within the 3 week period between user surveys \((n = 23)\).

<table>
<thead>
<tr>
<th>Subscale</th>
<th>M</th>
<th>SD</th>
<th>Range</th>
<th>t</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal</td>
<td>0.04</td>
<td>1.04</td>
<td>-4 to 2</td>
<td>-0.44</td>
<td>0.66</td>
</tr>
<tr>
<td>Powerful Others</td>
<td>-0.29</td>
<td>1.27</td>
<td>-10 to 6</td>
<td>1.21</td>
<td>0.24</td>
</tr>
<tr>
<td>Chance</td>
<td>-0.10</td>
<td>1.23</td>
<td>-6 to 5</td>
<td>0.51</td>
<td>0.61</td>
</tr>
</tbody>
</table>

**Table 9.7:** Participants’ responses for *Powerful Others* before and after using HC4L.

<table>
<thead>
<tr>
<th>No.</th>
<th>Statement</th>
<th>t stat</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Having regular contact with my doctor is the best way for me to avoid illness.</td>
<td>0.67</td>
<td>0.51</td>
</tr>
<tr>
<td>2</td>
<td>Whenever I don’t feel well, I should consult a medically trained professional.</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>3</td>
<td>Health professionals control my health.</td>
<td>2.34</td>
<td>0.03</td>
</tr>
</tbody>
</table>

**9.3.4. Motivation**

Table 9.8 on the following page presents the mean values and standard deviations of the five pre-selected subscales of the IMI (subscale range 1 to 7). It also illustrates the scores of two different age groups of seniors.

Excluding the “pressure/tension” scale, the results show mid scores in the range 4.11 to 4.40. The results imply that the participants were fairly interested in the system, were adequately competent, made a reasonable effort in using the system, and felt that the system has some value or utility for them. The “pressure/tension” subscale obtained a low score indicating that the participants did not experience stress while using the system. There
are significant differences between age groups for the scores for “perceived competence” and “value/usefulness”. Seniors within the age range 60 to 69 consider themselves more competent and find the system more valuable than older seniors.

Table 9.8.: Results of the IMI on a scale from 1 (strongly disagree) to 7 (strongly agree), showing the mean ± standard deviation and midpoint comparison for each subscale.

<table>
<thead>
<tr>
<th>Subscale</th>
<th>All (n = 24)</th>
<th>Age 60-69 (n = 12)</th>
<th>Age 70-85 (n = 12)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t</td>
<td>p-value</td>
<td></td>
</tr>
<tr>
<td>Interest/Enjoyment</td>
<td>4.40 ± 1.68</td>
<td>-2.15</td>
<td>4.42 ± 1.73</td>
</tr>
<tr>
<td>Perceived Competence</td>
<td>4.39 ± 1.78</td>
<td>-2.55</td>
<td>4.89 ± 1.52</td>
</tr>
<tr>
<td>Effort/Importance</td>
<td>4.11 ± 1.58</td>
<td>-0.32</td>
<td>4.11 ± 1.57</td>
</tr>
<tr>
<td>Pressure/Tension</td>
<td>2.61 ± 1.56</td>
<td>5.94</td>
<td>2.67 ± 1.45</td>
</tr>
<tr>
<td>Value/Usefulness</td>
<td>4.25 ± 1.81</td>
<td>-1.27</td>
<td>4.53 ± 1.83</td>
</tr>
</tbody>
</table>

9.3.5. User Satisfaction and Acceptability

Participants rated the usability of the system positively. Twenty-four users completed the survey using the SUS scale. Resulting scores ranged from 35 to 100, with a median of 65. The average SUS score was 68.33. Only two participants gave less than 50% of the maximum score. The adjective rating of the mean SUS score is “OK”, which indicates it is an acceptable system (Bangor et al., 2009).

Participants’ open-ended responses were useful in gaining insight into their perception of HC4L. The most frequent positive and negative comments are listed in Table 9.9 on the current page. The results below include responses from the survey (including comments from participants that did not complete the entire six week study) and the interviews. Participants’ responses to open-ended questions (direct quotes) are available in Appendix E.3 on page 184.

Table 9.9.: Most common positive and negative comments about HC4L.

<table>
<thead>
<tr>
<th>Positive Responses</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I like the idea of it.</td>
<td>26%</td>
</tr>
<tr>
<td>It is easy to use.</td>
<td>23%</td>
</tr>
<tr>
<td>The health applications are a great help to keep track of one’s health.</td>
<td>16%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Negative Responses</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorting out calories values for foods seems a lot of trouble (Calorie Calculator).</td>
<td>21%</td>
</tr>
<tr>
<td>I’m not so keen on the social Facebook-like aspects of the system.</td>
<td>18%</td>
</tr>
<tr>
<td>Limited applications.</td>
<td>15%</td>
</tr>
</tbody>
</table>
Table 9.10 on the next page presents the participants’ mean responses for additional items included in the final survey of the study, where users’ responses were measured using a 6-point scale from 1 (strongly disagree) to 6 (strongly agree). Table 9.11 on page 137 complements Table 9.10 by providing more details about the user responses to the final survey, listing the % for all possible choices.

Figure 9.3 summarises with whom the participants would share their activities/information in the system.

![Figure 9.3: Participants’ preference for sharing data about their HC4L activities/information.](image)

### 9.4. Discussion

The summative evaluation reveals that HC4L is straightforward to use and has potential in empowering seniors to take charge of their health. The system is well accepted by the participants although there were some concerns revolving around the limited content (i.e. health applications) and social features provided in the system.

Results show that participants were keen about the general concept of HC4L that addresses the patients instead of clinicians, and encourages them to play a more active role in their healthcare. To our knowledge, this is the first study that assesses the value of a web-based telehealth system which does not involve clinicians in the intervention. The majority of the respondents (80%) acknowledged that the system allows them to be more aware of their health. One participant (SP10) commented: “It makes you stop and think about what you are doing and helps to moderate behaviour.”
## Table 9.10: Questions from the final survey and user responses.

The table shows the number of responses (n), and the mean response (M), standard deviation (SD), and midpoint comparison (t and p-value). (M) on a scale from 1 (strongly disagree) to 6 (strongly agree). The final survey and user responses combined.

<table>
<thead>
<tr>
<th>No.</th>
<th>Statement</th>
<th>n</th>
<th>M</th>
<th>SD</th>
<th>t</th>
<th>p-value</th>
<th>% Agree*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I would use HC4L if there were more applications.</td>
<td>18</td>
<td>4.17</td>
<td>1.47</td>
<td>-1.93</td>
<td>0.04</td>
<td>72</td>
</tr>
<tr>
<td>2</td>
<td>A system like HC4L that provides access to a variety of health applications will reduce the</td>
<td>18</td>
<td>3.89</td>
<td>1.78</td>
<td>-0.93</td>
<td>0.18</td>
<td>72</td>
</tr>
<tr>
<td>3</td>
<td>Involvement of friends helped me to better manage my health through HC4L.</td>
<td>13</td>
<td>2.54</td>
<td>1.76</td>
<td>1.97</td>
<td>0.04</td>
<td>31</td>
</tr>
<tr>
<td>4</td>
<td>I would rather manage my health by myself, without anybody's involvement in HC4L.</td>
<td>18</td>
<td>3.56</td>
<td>1.69</td>
<td>-0.14</td>
<td>0.45</td>
<td>56</td>
</tr>
<tr>
<td>5</td>
<td>The social features of HC4L (e.g., making friends, sharing activity updates with each other,</td>
<td>15</td>
<td>2.6</td>
<td>1.45</td>
<td>2.40</td>
<td>0.02</td>
<td>33</td>
</tr>
<tr>
<td>6</td>
<td>The charts/graphs presented in HC4L helped me to understand my health progress better.</td>
<td>15</td>
<td>3.93</td>
<td>1.28</td>
<td>-1.31</td>
<td>0.11</td>
<td>80</td>
</tr>
<tr>
<td>7</td>
<td>HC4L has the potential to positively impact my life.</td>
<td>17</td>
<td>3.82</td>
<td>1.67</td>
<td>-0.80</td>
<td>0.22</td>
<td>65</td>
</tr>
<tr>
<td>8</td>
<td>HC4L simplifies health monitoring tasks that I found cumbersome to do before.</td>
<td>16</td>
<td>3.06</td>
<td>1.57</td>
<td>1.12</td>
<td>0.14</td>
<td>56</td>
</tr>
<tr>
<td>9</td>
<td>HC4L encourages me to be more aware of my health.</td>
<td>15</td>
<td>4.27</td>
<td>1.44</td>
<td>-2.07</td>
<td>0.03</td>
<td>80</td>
</tr>
<tr>
<td>10</td>
<td>HC4L has the potential to help seniors in dealing with social isolation.</td>
<td>18</td>
<td>4.27</td>
<td>1.35</td>
<td>-1.43</td>
<td>0.09</td>
<td>61</td>
</tr>
<tr>
<td>11</td>
<td>HC4L allows me to get in touch with other patients with a similar disease or health problem.</td>
<td>11</td>
<td>4.00</td>
<td>0.00</td>
<td>6.00</td>
<td>0.00</td>
<td>100</td>
</tr>
</tbody>
</table>

*Percent Agree (%) = Strongly Agree, Moderately Agree & Slightly Agree Responses combined.
Table 9.11.: Detailed summary of user responses to the final survey, listing the % for all possible choices.

<table>
<thead>
<tr>
<th>Statement No.</th>
<th>Strongly Agree</th>
<th>Moderately Agree</th>
<th>Slightly Agree</th>
<th>Slightly Disagree</th>
<th>Moderately Disagree</th>
<th>Strongly Disagree</th>
<th>N/A</th>
<th>Average Rating*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25% (5)</td>
<td>20% (4)</td>
<td>25% (5)</td>
<td>5% (1)</td>
<td>20% (4)</td>
<td>0% (0)</td>
<td>5% (1)</td>
<td>4.17</td>
</tr>
<tr>
<td>2</td>
<td>20% (4)</td>
<td>25% (5)</td>
<td>25% (5)</td>
<td>5% (1)</td>
<td>0% (0)</td>
<td>20% (4)</td>
<td>5% (1)</td>
<td>3.89</td>
</tr>
<tr>
<td>3</td>
<td>5% (1)</td>
<td>5% (1)</td>
<td>10% (2)</td>
<td>10% (2)</td>
<td>5% (1)</td>
<td>30% (6)</td>
<td>35% (7)</td>
<td>2.54</td>
</tr>
<tr>
<td>4</td>
<td>15% (3)</td>
<td>10% (2)</td>
<td>30% (6)</td>
<td>15% (3)</td>
<td>10% (2)</td>
<td>15% (3)</td>
<td>5% (1)</td>
<td>3.56</td>
</tr>
<tr>
<td>5</td>
<td>0% (0)</td>
<td>10% (2)</td>
<td>15% (3)</td>
<td>5% (1)</td>
<td>25% (5)</td>
<td>20% (4)</td>
<td>25% (5)</td>
<td>2.6</td>
</tr>
<tr>
<td>6</td>
<td>0% (0)</td>
<td>35% (7)</td>
<td>30% (6)</td>
<td>0% (0)</td>
<td>10% (2)</td>
<td>5% (1)</td>
<td>20% (4)</td>
<td>3.93</td>
</tr>
<tr>
<td>7</td>
<td>10% (2)</td>
<td>30% (6)</td>
<td>15% (3)</td>
<td>5% (1)</td>
<td>15% (3)</td>
<td>10% (2)</td>
<td>15% (3)</td>
<td>3.82</td>
</tr>
<tr>
<td>8</td>
<td>0% (0)</td>
<td>15% (3)</td>
<td>35% (7)</td>
<td>0% (0)</td>
<td>15% (3)</td>
<td>20% (4)</td>
<td>15% (3)</td>
<td>3.06</td>
</tr>
<tr>
<td>9</td>
<td>15% (3)</td>
<td>25% (5)</td>
<td>25% (5)</td>
<td>5% (1)</td>
<td>5% (1)</td>
<td>5% (1)</td>
<td>20% (4)</td>
<td>4.27</td>
</tr>
<tr>
<td>10</td>
<td>20% (4)</td>
<td>15% (3)</td>
<td>25% (5)</td>
<td>20% (4)</td>
<td>15% (3)</td>
<td>0% (0)</td>
<td>5% (1)</td>
<td>3.94</td>
</tr>
<tr>
<td>11</td>
<td>5% (1)</td>
<td>20% (4)</td>
<td>15% (3)</td>
<td>15% (3)</td>
<td>15% (3)</td>
<td>5% (1)</td>
<td>25% (5)</td>
<td>3.6</td>
</tr>
</tbody>
</table>

*Computed upon subtracting the number of participants that have responded “N/A” (not applicable)
The participants appreciated the intention of enabling them to access a wide variety of health applications via a single interface. Most of them (72%) agree that such functionality can reduce the need for them to visit different websites in managing their health. One of the participants (SP10) expressed: “I like the ability to monitor and check your weight, vitals and what exercise you had been doing on a daily basis.” Although the system had only a few health monitoring applications, they were well received by the participants, with the Vital Tracker and Exercise Tracker being the most popular (see Figure 9.2 on page 132).

An important lesson learned is that hosted applications must be carefully designed with seniors in mind. For example, the Calorie Calculator, a free iGoogle gadget added from LabPixies.com, was least liked and used by the participants. Issues reported include: the extreme tediousness of the application (SP6), the foods are mostly American (SP19), and it is not clear where to enter the data (SP1). This also illustrates that cultural and location-dependent issues can affect acceptance of applications. Other applications, which were specifically developed for HC4L, were regarded as interesting and useful. Most reported shortcomings can be easily corrected. For instance, the Multiplayer Memory Game was found to be more enjoyable than the commonly found single player memory games, but the participants were not able to play it often because no other participant was online at the same time. We also had participants which commented that they prefer to play the game by themselves. One participant (SP30) expressed: “I would like to be able to do memory games without having to play with someone I don’t know.”

Since HC4L was made accessible online for the study, participants expected it to be a fully functional and complete system, as demonstrated in the comment (SP5): “It is a good idea that needs smoothing out, because it has very limited programs at this stage.” The study indicates that there is a need for a wide variety of health applications tailored to the individual needs of the patients. At this stage, only 33% of the initial user group agreed to continue using the system. However, 72% of the participants stated they would be happy to continue using HC4L, if it contained more applications relevant to their needs. This indicates that seniors are ready to manage their own care via a web system provided that there are suitable health-related applications for them to use. Results obtained generally indicate that the limited content and customisation of the system is a reason for the reduced retention rate of the participants (as depicted in Figure 9.1 on page 132). Users can become bored and discouraged looking after their health if they are not supported with health applications to address their needs. This highlights the advantage of having a Facebook-like interface allowing submission of third-party content, but also demonstrates
the need for a large and active user community supporting the system.

Seniors usually rely on their clinicians to monitor their health (see Section 4.3.2 on page 46). Therefore, the elevation of self-care solutions such as HC4L, which do not involve clinicians, might result in adverse effects on a patient’s motivation to use such systems. Results of the intrinsic motivation scales show that participants rated their subjective experience with HC4L as satisfactory. Younger seniors (age 60 to 69), on the whole, yielded higher scores than the older seniors (age 70 and above), i.e. younger seniors are more motivated to leverage the system for their health. Overall, seniors were moderately motivated to use the system in managing their health despite the absence of clinicians. The SUS score also confirms that HC4L usability is satisfactory. Although a better score, 75, was obtained during the formative evaluation of the system (described in Chapter 8), there is a vast difference between the sample size and duration of the study. Moreover, the current mean SUS score is above 68, which Sauro (2011) determined as average of 500 evaluation studies.

There was some indication that the attitude of the user matters more in self-care solutions than the features provided in the system. For example, an interesting comment by one participant (SP4) was: “For elderly people to improve their quality of life as they age, a positive attitude is essential for well-being. Interaction with others in similar circumstances goes a long way in achieving this.”

The results of the MHLC scale, especially in the “powerful others” subscale, were encouraging and suggest that HC4L has the potential to positively affect users’ attitude that their health is not controlled by external forces such as health professionals. We hypothesise that this change resulted predominantly from enabling participants to monitor their health status, e.g. via the Vital Tracker and Exercise Tracker.

Although a few participants reported being unable to track their blood pressure due to the lack of the necessary equipment, the system enabled them to realise that some minor tasks usually done by health professionals, can be performed by the patient. In fact, HC4L allows users to collect more health related data than a doctor would usually do. For instance, patients can track the amount of exercise they perform within a week and make effective use of the visual feedback provided via charts and graphs to ensure they have done enough to improve or maintain their health. It was interesting to note that the majority of the respondents (80%) endorsed that the charts/graphs presented in HC4L enabled them to better understand their health progress. Overall, systems like HC4L, which are not meant to replace doctors, can allow patients to realise that they have the power to positively affect their well-being. We anticipate that with more useful
applications and a larger pool of users, the system would result in an even larger change of patients’ perspective towards managing their health. One participant (SP27) commented “I hope this programme will become more useful as time goes on and more people use it. I can visualise this in the future.”

In the present study, the social aspects of HC4L were not positively endorsed by the participants. The majority of the participants were not keen on using Facebook-like social features. This finding is consistent with the outcome of the formative evaluation of the system. The Facebook-like comment feature was retained after the formative study, but with a clear purpose - to enable patients to encourage each other in managing their own health. The main objective of the commenting feature was changed from mere sharing of messages to a place where patients could motivate each other for taking charge of their health via the applications provided in the system. Several other features were incorporated, such as the ability to automatically share health-related activity information (e.g. exercise tracking) with all friends in the system. Apart from writing positive comments, a thumb-up button was also provided, which could possibly give a visual encouragement to the patients.

However, user feedback on these features was mixed. Most of the participants (67%) feel that the social features did not motivate them to continue using the system, and 69% of them found the involvement of friends was not beneficial to their health. Four active participants of the study expressed disappointment that their friend requests were not responded to. One of them also shared that she started off with the study enthusiastically, but received only one friend response which caused the motivation to disappear. Most of the participants were not comfortable to accept strangers as “friends” in the system. This could be due to privacy issues, as a few participants made similar comments relating to their hesitation in sharing personal information with others. A typical comment was: “I would not share my medical details with someone I don’t know. - SP30”

A few participants commented that it is important for them to know someone well enough (e.g. what their goals are) before they could accept them in their friends list. One participant expressed: “I find the use of the word 'friends' for people I don’t know and will never meet very inappropriate and off-putting. Also it’s really important to learn more about the people in your circle so that you care enough about them and their goals to be able to offer support. Just giving them the thumbs-up because they say they’ve updated something seemed a bit pointless when you don’t have any idea of the significance of the update to them, nor any data to respond to.” It was very encouraging to see participants thinking deeply about the functionalities of the system. The response implies that users
would welcome purposeful feedback, but it is unclear how to achieve this without using an experienced human expert. Hence, the social networking functionalities of HC4L might still be useful, but not in the form we know from Facebook and similar sites.

The system could be especially valuable to people who are lonely, as 61% of the participants agreed that the system has the potential to help seniors deal with social isolation. Nevertheless, it is necessary to revise the social component in a way which fosters building personal relationships (possibly using a video conferencing facility), and which overcomes concerns of about privacy issues. The interviewed seniors seemed to be very careful in their selection of friends, which is in agreement with the literature (Lindley et al., 2008). This observation contrasts with younger users of social media sites, which are more open towards accepting friends and sharing personal information (Gross and Acquisti, 2005). Other ways of providing social support to patients in the system need to be explored. For example, it might be helpful to have subgroups for users with different health conditions, as done in the website PatientsLikeMe.com (Wicks et al., 2010), since this gives users a sense of commonality and belonging.

9.5. Conclusion

We described a summative evaluation of HC4L. The idea of leveraging the Web to manage health is well-accepted by seniors, but health applications need to be tailored towards individual needs (health conditions). The results demonstrate the need of having an extendable open system, where new applications can easily be added. Social networking functionalities are desired, but not in the common “open” form we might know from Facebook and similar social media sites.

Our results suggest that web-based telehealth systems have the potential to positively change the attitude of users towards their health management, i.e. users realise that their health is not controlled by health professionals, but that they have the power to affect their own well-being positively. Overall, results have been encouraging and systems like HC4L have great potential in letting seniors play an active role in their own care.
10. Conclusion and Future Work

Our thesis was motivated by the realisation that healthcare costs are consuming a rapidly increasing proportion of government expenditure, and new ways must be found to use healthcare resources more efficiently. Telehealth systems are a promising approach, but many existing systems are limited in their capabilities. Their usage is constrained by high initial costs and a design often centred around the requirements of the clinical user, healthcare provider, and the equipment vendor. Many existing systems cannot be extended by third parties, require extra costs to add new functionalities, are designed to manage diseases rather than prevent them, and do not address the social and psychological needs of the patient.

As a solution, we proposed HC4L, a novel web-based telehealth system, which is ubiquitous, extendable by third parties, and incorporates social networking aspects. In the previous chapters, we determined user requirements, developed and presented the design of the system, evaluated web technologies for their suitability to realise the developed design, and we presented the implementation of a prototype. A formative and summative evaluation of the system were conducted to evaluate the prototype. We focused on seniors with the aim of empowering them to manage their own care from home. A user-centred approach was employed in the system development process. Feasibility and acceptability of our web-based telehealth solution by seniors was investigated. This chapter highlights our contributions to the research field, draws conclusions from our research, puts them into context with similar research, and makes recommendations for future work.

In Section 10.1, we discuss and reflect on the outcome of this project broadly. Section 10.2 lists the major contributions and achievements of this project. Section 10.3 draws conclusions from the results we obtained and discuss a range of opportunities for telehealth research and practice. Section 10.4 discusses limitations of the study. Section 10.5 compares HC4L with other published tools. Finally, Section 10.6 points out future directions.
10.1. Discussion

This thesis explored novel ideas to address the shortcomings of current telehealth systems and Web 2.0 health applications. We proposed a framework for an accessible patient-centric telehealth system with social aspects, developed a prototype implementing key concepts, and explored these concepts using the prototype. The Web offers the advantage of enabling telehealth to be more accessible and social, and stimulates integration of third-party applications to address the diverse needs of patients and to overcome issues related to vendor lock-in. Therefore, we leveraged the Web to deliver healthcare services via the HC4L prototype to seniors. There are many monitoring devices but there is no clear standard as for the Web. This makes the Web the most standardised platform and hence a good choice to reach many users, including seniors.

The proposed solution, HC4L, is not a telehealth system in the traditional sense, i.e. to assist health professionals to monitor patients’ health progress. HC4L was designed through the eyes of senior healthcare consumers and it provides a new take on telehealth, enabling users to be more proactive in improving and even maintaining their health independently. Unlike existing consumer health informatics applications (discussed in Chapter 2 on page 11) that follow different objectives, HC4L is a generic system that could host a variety of health applications that can be grouped into categories such as monitoring, education and social support.

The involvement of health professionals are often emphasised in healthcare systems, but we created and evaluated a self-care telehealth application which embraces the power of social networks by creating a caring community, enabling patients to provide and to obtain social support to and from other patients. We extend the work of James Heywood who founded PatientsLikeMe.com, a successful patient network that has more than 220,000 registered users and allows them to share and learn from other patients that have experienced similar conditions (Wicks et al., 2010). Apart from learning from other patients, we extend the concept of empowering patients by enabling users to leverage tailored health support applications contributed by developers worldwide. HC4L was designed using an open architecture and several applications were created and hosted to test the ability to integrate third-party applications.

Existing self-care applications available on smartphones and tablets are becoming popular among consumers, but such applications are standalone (cannot be integrated with one another) and mostly target the younger generation. Novel social support applications are solely focussed to tackle social isolation. We proposed a hybrid approach that
integrate and deliver both the health and social applications to consumers via the same platform. At this stage, the aim was to test the concept of HC4L with seniors, i.e. to determine the feasibility and acceptance among target users and hence we did not link to any existing telehealth platforms or formal care systems. Previous studies indicated that seniors are not yet ready to adopt health-related systems (Heart and Kalderon, 2011). Our findings suggest that seniors are ready to leverage health-related ICT for their health as long as there are sufficient and adequate health applications that meet their unique needs.

The proposed framework presented in Chapter 5 on page 55 consists of various components and overall vision to empower healthcare consumers to take better care of their health. We conducted studies to establish the user requirements and received positive feedback on the initial idea as well as suggestions on features and applications to include in the proposed system. For instance, it was apparent that seniors wanted tailored health applications that meet their unique healthcare needs. Hence, we implemented an extendable system that could host third-party applications contributed by developers. The key design principles presented in Chapter 5 on page 61 summarise the user requirements that were addressed in the final version of the prototype.

On the whole, this thesis contributes to a novel design for web-based telehealth systems that is closely aligned with consumers’ preferences, i.e. telehealth from the perspective of the senior consumer. The design, development and evaluation of HC4L can be seen as an exemplar for developments to come. This thesis mainly contributes to the area of Telehealth and Consumer Health Informatics as well as other related fields such as Gerontechnology, HCI, Software Engineering, Health Informatics and Web 2.0.

A large portion of the participants of our user studies were mainly Europeans and there were a small number of Asians. The seniors were ranging from 60 to 90 years of age. Most of the participants were computer literate or use a computer quite comfortably. The ethnic distribution of seniors in New Zealand is predominantly European and will remain to be the largest ethnic group in the country (Ministry of Social Development, 2010). There are other small ethnic groups (below 10% of the total senior population) such as Asians, Maori and Pacific peoples. Therefore, the findings of this thesis reflect quite well to the general population of seniors in New Zealand that have some basic experience with computers.
10.2. Achievements and Contributions

Findings of our work are expected to be useful to researchers and developers of web-based healthcare solutions, especially those targeting the senior population. The following list highlights the major achievements of this project:

1. **A framework to overcome shortcomings of existing consumer health informatics applications.** We critically analysed existing consumer health informatics systems from the consumers’ perspective. Major barriers preventing a wider and more effective usage of these systems for healthcare were identified. In order to overcome these barriers, we developed a framework for a novel patient-centric telehealth system, which is ubiquitous, extendable by third parties, contains social aspects, offers cognitive engagement, and encourages users to take charge of their own health. The framework can be used by other researchers to improve existing telehealth solutions and develop novel computer-based tools for intervention.

2. **A taxonomy of usability requirements for home telehealth systems.** We identified common barriers preventing seniors from making effective use of telehealth systems, studied the usability problems of previous and current telehealth systems, and created a taxonomy of usability requirements. The taxonomy is expected to enable a more patient-centric solution. Such work is important in order to obtain a holistic view of the needs and current expectations of users towards telehealth systems.

3. **An interview study with seniors to elicit user requirements for a web-based telehealth system.** We conducted semi-structured interviews with a group of seniors to formulate the user interface and functional requirements for HC4L, as well as to obtain users’ perception towards a web-based solution. Screenshots of several existing Web 2.0 health applications and a paper-based prototype of our system were used to gain an insight into the needs and preferences of seniors. Overall, the respondents were positive about the idea of using the Web to manage their healthcare from home and made several suggestions such as including applications to manage their diet, physiotherapy exercises to improve their health condition, and simple network games to reduce loneliness. Results also indicate that seniors prefer a clean, icon-based and colourful user interface, which uses single horizontal menu at the top that enables them to identify and select key functionalities easily.

4. **A review of Web 2.0 technologies for developing web-based telehealth systems.**
We studied some of the most popular social networking APIs and web development tools, and evaluated them with regard to the requirements of a patient-centric tele-health system (i.e. an extendable telehealth system which incorporates social networking capabilities). Our findings indicate that the OpenSocial API is supported with a stable reference implementation (Apache Shindig) to realise the integration of third-party applications. Unlike Facebook, OpenSocial does not constrain developers to proprietary regulations. The Drupal CMS is favoured over other web development tools, as it offers the advantages of both WAFs and CMSs (a hybrid approach) and is supported with a readily available module (Shindig-Integrator) to integrate the Apache Shindig OpenSocial container. Our review and the implementation of HC4L confirm that both the OpenSocial and Drupal CMS integrate well and are suitable to build an extendable web-based telehealth system with social capabilities.

5. **The design and development of a web-based telehealth system.** We developed a novel patient-centric telehealth system, which is extendable by third parties, contains social aspects and is presented with a user-friendly user interface. Several health monitoring applications (e.g. weight, exercise and vitals tracker) including a social memory game were designed and deployed on this system. This system opens new opportunities for researchers and developers to contribute health support applications in HC4L to extend its capabilities. The design principles and methodology (i.e. participatory design process) employed in the development of HC4L can be used by other researchers to enhance existing or develop novel web-based telehealth solutions.

6. **Evaluation of a web-based telehealth system.** We conducted a formative and a summative evaluation to identify the usability problems of HC4L and to assess the feasibility and acceptability of the concept. The evaluation of our prototype indicates that combining telehealth functionalities with social components and user-generated content is a promising way to enable users to proactively manage and improve their health. Our research provides an insight into the use of a web-based telehealth system for seniors. Results generally indicate that seniors are ready and motivated to leverage a web-based telehealth system which offers a comprehensive suite of health-related applications for their healthcare, as long as there are suitable applications tailored to their health needs. Our investigation into the use of social networking features gave mixed results and we encountered two distinct types of
reactions: (1) users who want social support as a motivation in looking after their health and dealing with social isolation; and (2) users who are not keen on involving anyone in the management of their health. Our research showed that social features are desired in a telehealth system, but not in the open form found commonly in existing social networking sites like Facebook. This reinforces an impression that although social networking sites like Facebook are popular, they are not necessarily a suitable platform to deliver health-related applications to consumers in general.

10.3. Conclusions

Telehealth is a broad and an important subject area that has received increased attention from developers and health consumers. The research presented in this thesis contributes in a small way to this field. We proposed and tested a novel open, generic and patient-centric telehealth system that is not confined to specific conditions. We believe that this is a stepping stone in reaching a practical solution that will meet the unique needs and demands of health consumers when looking after their health, especially as a tool for health education and preventive medicine.

Existing telehealth systems are tailored towards clinical users. We have shown that it is possible to develop a patient-centric telehealth system using Web 2.0 technology, and that the overall idea was well accepted by healthcare consumers. Crucial for the success of the application is a sufficiently large user community and developer support. This means in particular that future versions of this application need to take into account the needs of content contributors, i.e. the software must become more attractive to researchers and developers.

Recent research by Sanders et al. (2012) indicates that barriers to adoption of novel telehealth systems by seniors go beyond common concerns such as privacy and technophobia. Our research confirmed that healthcare consumers have widely varying needs. Not meeting these needs limits acceptance and usage of the software. Some applications, such as weight trackers, exercise trackers and memory games, are useful to the majority of users. However, patient-specific needs, in particular those related to health conditions, must also be taken into account. With increasing popularity, the number of applications in HC4L might become difficult to manage and new tools for this need to be developed. One possibility is to create default settings for specific health conditions. For example, a user with diabetes would by default use a medication reminder and applications for tracking diet, exercises, and vital signs.
The users’ attitude towards social networking functionalities was mixed. On the one hand, users confirmed that social isolation is an important issue, and many users expressed the desire to make new friends online. On the other hand, many users felt uncomfortable to become friends with somebody not personally known, and there were privacy concerns. It has become clear that Facebook-style social media functionalities cannot be directly transferred to healthcare applications. Researching this issue is a major direction of future work. One possibility is to allow users to get to know each other better, e.g. by video chat, in order to build up trust. Another direction is to allow users to assume a new identity without any links to their real identity, similar to the model used in SecondLife.com\textsuperscript{1} and other virtual worlds.

An important result of our research is that patient-centric telehealth systems has the potential to change users’ attitude towards their health management, i.e., empower patients and reduce doctor reliance. Longer term studies with larger patient populations are necessary to confirm and quantify these results. More health psychology research needs to be incorporated into HC4L, e.g. to raise patients’ awareness of symptoms, to motivate them to make positive lifestyle changes, and to increase patient compliance. This could be achieved by using visualisations and pictorial content, which has been successfully used in the public health domain, e.g. for anti-smoking campaigns.

Seniors are often said to experience anxiety and usability issues when dealing with technology, but the trend is changing. Our research showed that seniors with basic web browsing skills are able and ready to leverage the Web for their healthcare. The idea of leveraging a web-based telehealth system with social support from likeminded users is well accepted, but it will take time for this concept to mature. Convincing older seniors (aged 80 and above) in using a self-care tool like HC4L remains a challenge. Many of them would like to avoid computers, live a simple life and maintain their current lifestyle of letting their doctors take care of their health. Systems like HC4L can benefit users but require commitment from them to be useful.

Although we have involved potential users in the design of our system from the very outset, it became clear that getting the right requirements for a generic system targeted at the senior population is a challenge. Seniors include people with a wide variety of backgrounds that have a lot of experience in dealing with life challenges including health issues. They tend to have strong opinions and different expectations towards self-care solutions, which we anticipate will keep changing in the future. There does not seem to be a single, fixed solution that fits all of them, but a personalised system with applications

\textsuperscript{1}A free online 3D virtual world that enable users to socialise with each other through avatars.
which are tailored to their unique needs is necessary. In order to achieve this in HC4L, more applications need to be developed and deployed. This involves much more work than is feasible for a PhD project, so a team effort is necessary to take the HC4L project to the next level.

### 10.4. Limitations

The HC4L vision covers a large scope and therefore only essential features of the framework were implemented. Only a few health applications were developed and most of the applications created concentrate on health monitoring. Although the system was intended for two groups of users, i.e. healthcare consumers and application developers, our focus was on healthcare consumers, especially seniors, in ensuring that the overall concept was feasible and accepted by them.

Due to the shortage of resources and time, only seniors with basic computer experience were engaged in the formative evaluation study (presented in Chapter 8), as they were anticipated to provide useful feedback and recommendation to improve the system. Although we believe that the participants of this study were representative of the potential users of a web-based telehealth system, the sample size used was relatively small. The mathematical model of Nielsen indicates that five real users are sufficient to detect the majority (85%) of the usability problems of a website (Nielsen, 2000), but other researchers have argued that a larger sample is necessary to obtain reliable data.

Most participants of the summative evaluation (presented in Chapter 9) had experience with computers and results for users unfamiliar with computers may differ. The relatively small size of the sample did not allow us to determine whether the system is more useful for some subgroups than others (e.g. particular health issues, psychological or emotional conditions). We also did not provide the necessary equipment, such as blood pressure measuring devices and glucometers, to enable the participants to read their vital sign data.

### 10.5. Comparison with Similar Systems

The past decade has seen rapidly increasing interest amongst system developers, researchers, and healthcare providers in the area of telehealth, patient empowerment and recently in the use of social networks for healthcare. In this section we compare emerging OpenSocial-based telehealth systems with HC4L. First, we provide an overview of
the selected framework/system, and then we compare the essential characteristics with HC4L.

### 10.5.1. Leveraging Social Networks in Telehealth Solutions

Weitzel et al. (2009) proposed a framework for participatory telehealth that describes how patient monitoring can be enhanced via “network effect” - the collection of insights and views of people who are in close contact with the patient (e.g. family and friends). The aggregated information, such as mood, behaviour, and observation data, can be captured from family and friends via an OpenSocial-based application on a social network, which can instantly be presented to the healthcare providers remotely through a web-based system. The OpenSocial API also allows healthcare providers to access other valuable information, such as data extracted from health applications used by the patient (e.g. Meal Planner & Calorie Counter) or a social graph of the patient, including emergency contacts. Essentially, the framework enables healthcare providers to obtain a comprehensive view of the current health condition of the patient.

From the above summary, it is apparent that the framework focuses on a particular aspect of telehealth: patient monitoring. Based on our understanding, systems developed by following the suggested framework could be more suitable to manage patients with a chronic disease (e.g. cardiovascular disease) where constant monitoring of health conditions or status is critical. HC4L covers a broader scope, as it is a generic open system aimed at hosting a variety of applications in meeting the different needs of patients (see Section 5.1 on page 55). Weitzel et al. (2009)’s proposed framework, similar to a typical telehealth system, directly involves healthcare providers/clinicians in the patient care process. Feedback generated from the system (i.e. inputs from people in close contact with the patient) is solely provided to the healthcare providers. This is a contrast to HC4L, where the patients are provided with feedback on their health progress (using graphical representations) and encouraged to develop protective behaviour before serious health conditions emerge which require medical attention. However, we embrace the idea of involving family and friends in the care process (as indicated in Section 5.1.4 on page 59).

### 10.5.2. A Web 2.0 Model for Patient-centered Health Informatics Applications

Weitzel et al. (2010) expand on the work from Weitzel et al. (2009) and propose a technical model describing how the OpenSocial specification can be leveraged to empower
healthcare professionals in providing better treatments and making better medical decisions by following effective medical protocols. The idea is to encapsulate and deliver medical protocols for use in clinical situations via a web browser in the form of OpenSocial gadgets, which can be adapted and adjusted in meeting the needs of the healthcare professionals. Healthcare providers can add the intended OpenSocial gadgets to their dashboards (i.e. patient’s visual healthcare record) to manage, monitor, and share information with other healthcare professionals. The distributed nature of gadgets can be harnessed to determine the protocol’s effectiveness, enabling healthcare professionals to take an agile approach to improve the protocol.

It is evident that the above model is targeted towards the healthcare professionals, and does not involve the patients. Such system could improve the delivery of care in the long run (i.e. the outcome of improved medical protocols), but neither will it encourage the patient to play an active role in their healthcare nor will it foster positive behaviour change towards managing health. However, the idea of improving the effectiveness of medical protocols can be exemplified in HC4L. For instance, we can extend the OpenSocial API to measure the effectiveness of health support applications that are created for a specific disease, in complementing the current application rating system described in Section 5.3.2 on page 73.

10.5.3. Participatory and Persuasive Telehealth

Lee et al. (2011a) presented a participatory and persuasive telehealth system as a solution to overcome limitations of traditional telehealth systems, i.e., to promote healthy lifestyles and counter patients’ resistance to change. The proposed framework incorporates the “action-based behaviour” model (Lee et al., 2010) in an attempt to affect and change patient behaviour. It also emphasises the use of social networks as a persuasive tool in telehealth systems, as well as to achieve effective and meaningful interactions between patients, healthcare professionals, and people close to the patients (via the OpenSocial API). Such interaction can assist in setting appropriate care goals and obtaining a better view of the patient’s overall status and well-being. People in close contact with patients are supported to deliver useful information related to a patient via OpenSocial gadgets that will be transmitted to the healthcare providers to take the necessary action, i.e., recommend an appropriate OpenSocial gadget to the patient or contact the patient about any abnormal trends.

The above framework, similar to preceding works discussed above, is mostly created to aid healthcare professionals in delivering better care to the patients. It requires strong
commitment from the often busy and expensive healthcare providers to be effective. The focus has been on gathering data from people around the patient (e.g. family and friends) to support health professionals in the care process, with little focus on empowering the patients to take charge on their own health. In other words, the patient depends on the healthcare provider to recommend suitable applications and make decisions for them. In HC4L, the patients are encouraged to take charge - they set their own goals, use appropriate applications added from the applications directory, and follow their health progress via easy-to-understand charts. Furthermore, unlike HC4L, the proposed ideas of Lee et al. (2011a) have not been tested with end users, which we believe is crucial in assessing the feasibility and acceptance of the concepts by intended users.

10.6 Future Work

The proposed HC4L framework covers a broad scope and the initial prototype encompassing the core features have obtained encouraging results. Hence, there are many opportunities to enhance HC4L. Several suggestions are summarised below.

More health support applications should be developed and deployed, ideally be designed in collaboration with health professionals. Most importantly, the applications should promote exercise and physical activity. Our review of existing consumer-level sensing devices (e.g. Wiimote, Kinect, and smartphones), published in Dhillon et al. (2012b), showed that these devices are open, enabling developers to take them beyond their traditional usage into areas such as physical therapy and rehabilitation. The key advantages of these devices are their motion-sensing capabilities that can be integrated into the user’s physical environment to collect on-body, freehand, and mobile health monitoring information and to initiate corresponding actions or alarms. Handsfree sensing devices such as the Kinect are likely to be suitable for a wide range of patients, especially seniors. Often, the amount of activity or exercise performed using a particular device is recorded within the individual device or system. Such data is crucial and need to be shared to allow health consumers to keep track of their health-related activity. Carroll et al. (2007) initiated an interoperable personal health system with a focus on device connectivity and interoperability guidelines, which can be adapted in integrating consumer-level sensing devices with HC4L.

Once sufficient content has been incorporated, the long-term effects of HC4L need to be explored in a longitudinal study with a larger sample of seniors. In order to evaluate the effectiveness of HC4L, we need to develop applications that are tailored towards common
health diseases and conditions seniors face as they age (e.g. diabetes, stroke, and demen-
tia), recruit participants that have such problems (possibly collaborate with senior care
centres to obtain sufficient numbers of participants) and execute an in situ study. In addi-
tion, we would want to confirm our findings that personal telehealth systems like HC4L
have the potential to change the behaviour of patients towards their health management.

The mixed results we obtained from the social features incorporated in HC4L draw our
attention to exploring and investigating new ways that would appeal to seniors in general
and encourage the use of HC4L. The social network should have a clear purpose and
should attract users to the community and towards getting involved naturally. The social
features should increase the social contacts of the user and instil a sense of mutual care
while alleviating privacy concerns. It is also important to make such features optional,
i.e., to cater for seniors that have negative attitudes towards social media. Furthermore,
the user interface of the social networking feature, i.e. Figure 5.6 on page 66 should to
be simplified. In addition to the standard commenting screen, we should investigate the
integration of the Skype API to enable users to make direct video calls from the system
to other patients, i.e. to get to know each other better, to understand their healthcare goals
and to build trust.

The OpenSocial technology allows applications to share data by using the persistence
API, but it does not support unifying data elements that can relate different types of data.
Different exercise games might use different measures to record users’ physical activities,
e.g. “calories burned” and “perceived-level-of exertion” scale similar to those used in
gym equipment. Such data should be unified so that they can be used by monitoring
applications to enable users to design activity plans and track progress. We need to explore
the use of a triplestore database, where data entities are composed of subject-predicate-
object triples (the predicate represents the unifying element).

It would be useful to appropriately quantify user’s health into a single score in HC4L.
The summative Healthcare4Life score included in the prototype collates the measures of
individual applications and weights them equally to provide a simple average. We need
to investigate other means of computing a single health score indicating patients’ health
status in HC4L by working closely with health professionals.

A major aspect of HC4L is the plug-in feature enabling developers to contribute health
applications. The plug-in feature was successfully implemented, but more support tools
for developers are needed before the system is ready for deployment. For instance, it is
necessary to develop a sandbox (i.e. a testing environment) to enable developers to trial
run their applications prior to uploading them into HC4L. Also, the system should be
tested with application developers to consider their feedback and suggestions.

From the design side, there are also very complex issues about how to motivate people to be active in their own care and addressing such issues of motivation and possibly behaviour change by referencing the vast literature in both psychology and in HCI/ehealth. The challenge of how to interpret these theories of motivation into the design of telehealth systems could be valuable.
A. Publications

This thesis resulted in the following fully refereed international publications (the main author of these publications goes by both 'Singh' and 'Dhillon').


Other publications derived from this thesis are:


Selected screens from the HC4L paper prototype that was shown to study participants during the interview session for requirements collection are provided on the following pages:
Figure B.1.: Applications added from application directory by the user.
Figure B.2.: Application executed in the canvas view.
Figure B.3.: List of applications in the application directory.
Figure B.4: Developer’s page to upload an application into HC4L.
C. Interview Study

C.1. Individual Participant Profile

<table>
<thead>
<tr>
<th>ID</th>
<th>Age</th>
<th>Gender</th>
<th>Ethnicity</th>
<th>Computer Usage</th>
<th>Uses Facebook</th>
<th>Living Arrangement</th>
<th>Living Circumstances</th>
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</tr>
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<td>Indian</td>
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<td>Home</td>
<td>Spouse/partner</td>
</tr>
<tr>
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<td>Alone</td>
</tr>
<tr>
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<td>Alone</td>
</tr>
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</tr>
</tbody>
</table>

C.2. Interview Protocol

1. How often do you use the computer? If you don’t use, please explain why?

2. What do you use it for?
   (E.g. email, blogging, Skype, games, socialise (e.g. Facebook), search information, etc.)

3. Do you face any problems while using the computer to perform your desired activities?
   (E.g. registration forms, remembering many passwords, complicated interfaces, not user-friendly interfaces, confusing navigation, etc.)

4. Do you use the Web to look for information related to your health? How often?

5. Were you able to find the desired information?

6. What is your opinion about using the Web to sustain and manage health from home?
   (E.g. exercise games, weight management system, yoga, etc.)
7. Are you using any health system to manage your health? Please elaborate. (E.g. DailyStrength, DailyBurn, Myfitnesspal, etc.)

8. Which games/computer games have you played or you like to play? (E.g. Dancetown, Wii Fit, Kinect, etc.)

9. How often do you visit the doctor?

10. How do you monitor your health currently?

11. Do you need reminders to attend doctors’ appointments/medication/diet?

12. How are you managing or maintaining your health condition? (E.g. Yoga, exercise, healthcare system, etc.)

13. Is it important to keep track of all the activities you do to manage your healthcare?

14. Do you like the idea of playing simple health games together with your family and friends over the Web?

15. What features or functionalities would you like to see in the new system? (E.g. Memory games, weight management, exercise games, chatting, video calls, etc.)

16. Do you ever feel lonely?

17. How do you socialise or keep in touch with your family and friends? (E.g. Home visits, phone, Skype, Facebook)

18. Could you imagine socialising by using computers?

19. Do you have a Facebook (or any other social network) page?

20. How often do you visit Facebook?

21. Do you face any problems using the Facebook?

22. What features do you like most and what do you dislike about the Facebook?

23. What do you think of these system interfaces?

24. What do you like and dislike about these pages? (E.g. layout, color, font, content, navigation)

25. Is there any useful function you would like to see in the new system?

26. What do you think could have been better?
D. Formative Evaluation

D.1. Individual Participant Profile

<table>
<thead>
<tr>
<th>ID</th>
<th>Age</th>
<th>Gender</th>
<th>Ethnicity</th>
<th>Computer Usage</th>
<th>Uses Facebook</th>
<th>Uses a Self-care tool</th>
<th>Living Circumstances</th>
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<td>Alone</td>
</tr>
<tr>
<td>FP6</td>
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<td>5+ days/week</td>
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<td>No</td>
<td>Spouse/partner</td>
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<td>F</td>
<td>European</td>
<td>1-4 days/week</td>
<td>Yes</td>
<td>No</td>
<td>Spouse/partner</td>
</tr>
<tr>
<td>FP8</td>
<td>68</td>
<td>F</td>
<td>Asian</td>
<td>5+ days/week</td>
<td>No</td>
<td>Yes</td>
<td>Spouse/partner</td>
</tr>
</tbody>
</table>

D.2. Evaluation Questionnaires

The questionnaire used for the formative evaluation is reproduced on the following six pages.
A Formative Evaluation of Healthcare4Life

Questionnaire

Researcher: Jaspaljeet Singh Ranjit Singh

Email: jaspaljeet@gmail.com

Participant No: ____________________
Date: ____________________
**Demographic Information**

1. What is your age? ______

2. What is your gender?
   - Male
   - Female

3. What is your ethnicity?
   - NZ-European
   - Māori
   - Asian
   - Other (specify): ________________

4. How frequently do you use computers?
   - 5 days a week or more
   - 1-4 days a week
   - 1-3 times a month
   - Less often than once a month
   - Never

5. Are you using any social networking website (e.g. Facebook)?
   - If yes, please specify:
   - No

6. Are you using any self-care tools in managing your health? (e.g. a blood pressure cuff, iPhone App)
   - If yes, please specify:
   - No
Chapter D
Formative Evaluation

Functionality

Order the following functionalities by their importance, starting with the functionality that is most important for you.

- Facebook-like comment feature
- Access to health-related applications (e.g. Memory Game)
- Play social games with friends
- Perform/view application ratings
- Send a message to a friend
- Add and remove applications
- Add and remove friends
- Search for friends and invite others to join Healthcare4Life
- Keep caregiver/family member informed about activities in the system
- View health data using graphs/charts (e.g. progress of your weight loss)
- Track the total amount of physical & mental exercise you have performed

Usability

For the following questions, please tick [✓] the box that matches your view most closely.

1. I think that I would like to use this system frequently.
   - Strongly Agree
   - Agree
   - Neutral
   - Disagree
   - Strongly Disagree

2. I found the system unnecessarily complex.
   - Strongly Agree
   - Agree
   - Neutral
   - Disagree
   - Strongly Disagree

3. I thought the system was easy to use.
   - Strongly Agree
   - Agree
   - Neutral
   - Disagree
   - Strongly Disagree

4. I think that I would need the support of a technical person to be able to use this system.
   - Strongly Agree
   - Agree
   - Neutral
   - Disagree
   - Strongly Disagree
<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>5.</td>
<td>I found the various functions in this system were well integrated.</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Neutral</td>
</tr>
<tr>
<td>6.</td>
<td>I thought there was too much inconsistency in this system.</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Neutral</td>
</tr>
<tr>
<td>7.</td>
<td>I would imagine that most people would learn to use this system very quickly.</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Neutral</td>
</tr>
<tr>
<td>8.</td>
<td>I found the system very cumbersome to use.</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Neutral</td>
</tr>
<tr>
<td>9.</td>
<td>I felt very confident using the system.</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Neutral</td>
</tr>
<tr>
<td>10.</td>
<td>I needed to learn a lot of things before I could get going with this system.</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Neutral</td>
</tr>
</tbody>
</table>

**User Interface**

For the following questions, please tick [ √ ] the box that matches your view most closely.

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>The horizontal menu appearing at the top makes it easy to identify the key functionalities of the system.</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Neutral</td>
</tr>
<tr>
<td>2.</td>
<td>The information on the site is organised clearly.</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Neutral</td>
</tr>
</tbody>
</table>
3. The icons helped in finding things in the site faster.  
<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

4. It is easy to navigate through the website.  
<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

5. The graphics on this web-site are visually pleasing.  
<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

6. The colour scheme used for this website is appropriate.  
<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

7. The fonts are easy to read.  
<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

8. The links and buttons in the website do what I expect them to do.  
<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

9. The used icons represent the corresponding functions well.  
<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

10. I feel lost when using this website.  
    | Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree |
    | --------------- | ------| ------- | -------- | -----------------|

11. The text on the website is easy to understand.  
    | Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree |
    | --------------- | ------| ------- | -------- | -----------------|
Interview Questions

1. What are the things you liked best about Healthcare4Life?
2. What are the things you liked least about Healthcare4Life?
3. What other functionalities would you like to see in Healthcare4Life?
4. Do you have any additional comments?

Thank you for your time and valuable feedback!
E. Summative Evaluation

E.1. Individual Participant Profile

<table>
<thead>
<tr>
<th>ID</th>
<th>Age</th>
<th>Gender</th>
<th>Ethnicity</th>
<th>Computer Usage</th>
<th>Uses Facebook</th>
<th>Uses a Self-care tool</th>
<th>Aware about Telehealth</th>
<th>Computer Skill Level</th>
<th>Living Circumstances</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP1</td>
<td>71</td>
<td>F</td>
<td>NZ-European</td>
<td>5+ days/week</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Intermediate</td>
<td>Alone</td>
</tr>
<tr>
<td>SP2</td>
<td>61</td>
<td>F</td>
<td>NZ-European</td>
<td>5+ days/week</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Advanced</td>
<td>Alone</td>
</tr>
<tr>
<td>SP3</td>
<td>66</td>
<td>F</td>
<td>NZ-European</td>
<td>1-4 days/week</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Advanced</td>
<td>Spouse/partner</td>
</tr>
<tr>
<td>SP4</td>
<td>85</td>
<td>F</td>
<td>NZ-European</td>
<td>5+ days/week</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Intermediate</td>
<td>Alone</td>
</tr>
<tr>
<td>SP5</td>
<td>46</td>
<td>F</td>
<td>NZ-European</td>
<td>5+ days/week</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Expert</td>
<td>Spouse/partner</td>
</tr>
<tr>
<td>SP6</td>
<td>76</td>
<td>F</td>
<td>NZ-European</td>
<td>5+ days/week</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Intermediate</td>
<td>Alone</td>
</tr>
<tr>
<td>SP7</td>
<td>75</td>
<td>M</td>
<td>NZ-European</td>
<td>5+ days/week</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Advanced</td>
<td>Spouse/partner</td>
</tr>
<tr>
<td>SP8</td>
<td>63</td>
<td>F</td>
<td>NZ-European</td>
<td>5+ days/week</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Advanced</td>
<td>Spouse/partner</td>
</tr>
<tr>
<td>SP9</td>
<td>65</td>
<td>F</td>
<td>NZ-European</td>
<td>5+ days/week</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Advanced</td>
<td>Spouse/partner</td>
</tr>
<tr>
<td>SP10</td>
<td>50</td>
<td>M</td>
<td>NZ-European</td>
<td>5+ days/week</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Advanced</td>
<td>Spouse/partner</td>
</tr>
<tr>
<td>SP11</td>
<td>72</td>
<td>F</td>
<td>NZ-European</td>
<td>5+ days/week</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Intermediate</td>
<td>Spouse/Partner</td>
</tr>
<tr>
<td>SP12</td>
<td>74</td>
<td>M</td>
<td>NZ-European</td>
<td>5+ days/week</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Intermediate</td>
<td>Spouse/Partner</td>
</tr>
<tr>
<td>SP13</td>
<td>71</td>
<td>F</td>
<td>NZ-European</td>
<td>5+ days/week</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Intermediate</td>
<td>Alone</td>
</tr>
<tr>
<td>SP14</td>
<td>70</td>
<td>M</td>
<td>NZ-European</td>
<td>5+ days/week</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Advanced</td>
<td>Alone</td>
</tr>
<tr>
<td>SP15</td>
<td>74</td>
<td>M</td>
<td>NZ-European</td>
<td>5+ days/week</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Intermediate</td>
<td>Alone</td>
</tr>
<tr>
<td>SP16</td>
<td>65</td>
<td>F</td>
<td>Asian</td>
<td>1-3 times/month</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Intermediate</td>
<td>Alone</td>
</tr>
<tr>
<td>SP17</td>
<td>61</td>
<td>M</td>
<td>NZ-European</td>
<td>5+ days/week</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Intermediate</td>
<td>Spouse/Partner</td>
</tr>
<tr>
<td>SP18</td>
<td>67</td>
<td>F</td>
<td>NZ-European</td>
<td>5+ days/week</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Intermediate</td>
<td>Spouse/Partner</td>
</tr>
<tr>
<td>SP19</td>
<td>68</td>
<td>F</td>
<td>NZ-European</td>
<td>5+ days/week</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Advanced</td>
<td>Spouse/Partner</td>
</tr>
<tr>
<td>SP20</td>
<td>72</td>
<td>F</td>
<td>Asian</td>
<td>1-4 days/week</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Intermediate</td>
<td>Alone</td>
</tr>
<tr>
<td>SP21</td>
<td>69</td>
<td>F</td>
<td>NZ-European</td>
<td>5+ days/week</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Novice</td>
<td>Alone</td>
</tr>
<tr>
<td>SP22</td>
<td>77</td>
<td>F</td>
<td>NZ-European</td>
<td>5+ days/week</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Novice</td>
<td>Alone</td>
</tr>
<tr>
<td>SP23</td>
<td>81</td>
<td>M</td>
<td>NZ-European</td>
<td>5+ days/week</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Intermediate</td>
<td>Spouse/Partner</td>
</tr>
<tr>
<td>SP24</td>
<td>68</td>
<td>F</td>
<td>NZ-European</td>
<td>1-4 days/week</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Novice</td>
</tr>
<tr>
<td>SP25</td>
<td>85</td>
<td>F</td>
<td>NZ-European</td>
<td>5+ days/week</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Intermediate</td>
<td>Alone</td>
</tr>
<tr>
<td>SP26</td>
<td>70</td>
<td>F</td>
<td>NZ-European</td>
<td>5+ days/week</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Advanced</td>
<td>Spouse/Partner</td>
</tr>
<tr>
<td>SP27</td>
<td>76</td>
<td>F</td>
<td>NZ-European</td>
<td>5+ days/week</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Intermediate</td>
<td>Alone</td>
</tr>
<tr>
<td>SP28</td>
<td>54</td>
<td>M</td>
<td>NZ-European</td>
<td>5+ days/week</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Expert</td>
<td>Spouse/Partner</td>
</tr>
</tbody>
</table>
E.2. Evaluation Questionnaires

Questionnaires of the summative evaluation were made accessible online to participants. The original questions were created using SurveyMonkey and the actual layout of the questionnaires as it was presented to the participants is illustrated in Figure E.1. The three sets of questionnaires (following the original order) with response choices are listed in the subsequent sections.

### E.2.1. Initial Questionnaire

This questionnaire was completed by all attendees of the introduction session. It consisted of two pages, where the first page was about collecting demographic information about participants and the second page was to obtain their general attitude towards healthcare.

#### E.2.1.1. Demographic Information

1. In what year were you born? (enter 4-digit birth year; for example, 1976)

2. Are you male or female?
   - [ ] Male
   - [ ] Female
E.2 Evaluation Questionnaires

Figure E.1.: Screenshot of the online survey as seen by the participants.

3. What is your ethnicity?
   [ ] NZ-European
   [ ] Māori
   [ ] Asian
   [ ] Other. Please specify: [ ]

4. Who are you living with?
   [ ] Alone
   [ ] Spouse/partner
   [ ] Children

5. How frequently do you use computers?
   [ ] 5 days a week or more
   [ ] 1 - 4 days a week
   [ ] 1 - 3 times a month
   [ ] Less often than once a month
   [ ] Never

6. How would you rate your computer skill level?
   [ ] Expert
   [ ] Advanced
7. Have you heard about telehealth?
   [ ] Yes
   [ ] No

8. Are you using any social networking website (e.g. Facebook)?
   [ ] Yes
   [ ] No
   If Yes, please specify: [ ]

9. Are you using any self-care tools in managing your health (e.g. blood pressure cuff, glucometer, health website)?
   [ ] Yes
   [ ] No
   If Yes, please specify: [ ]

E.2.1.2. Attitude towards Healthcare

Instruction: Please rate the following statements based on this scale:

<table>
<thead>
<tr>
<th></th>
<th>Strongly Agree</th>
<th>Moderately Agree</th>
<th>Slightly Agree</th>
<th>Slightly Disagree</th>
<th>Moderately Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

1. No matter what I do, if I am going to get sick, I will get sick.
2. Having regular contact with my doctor is the best way for me to avoid illness.
3. Whenever I don’t feel well, I should consult a medically trained professional.
4. Health professionals control my health.
5. My good health is largely a matter of good fortune.
6. The main thing which affects my health is what I do myself.
7. If I take care of myself, I can avoid illness.
8. If it’s meant to be, I will stay healthy.
9. If I take the right actions, I can stay healthy.
E.2 Evaluation Questionnaires

E.2.2. Interim Questionnaire

This questionnaire consisted of four pages. The first page was about participants’ attitudes towards healthcare in general. The second page asked about their subjective experience when using the HC4L. The third page asked how easy they found it using use the HC4L. The fourth page was about participant’s general opinion about the HC4L.

E.2.2.1. Attitude towards Healthcare

Instruction: Please rate the following statements based on this scale:

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Moderately Agree</th>
<th>Slightly Agree</th>
<th>Slightly Disagree</th>
<th>Moderately Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

1. No matter what I do, if I am going to get sick, I will get sick.
2. Having regular contact with my doctor is the best way for me to avoid illness.
3. Whenever I don’t feel well, I should consult a medically trained professional.
4. Health professionals control my health.
5. My good health is largely a matter of good fortune.
6. The main thing which affects my health is what I do myself.
7. If I take care of myself, I can avoid illness.
8. If it’s meant to be, I will stay healthy.
9. If I take the right actions, I can stay healthy.

E.2.2.2. User Motivation

Instruction: Please rate the following statements based on this scale:

<table>
<thead>
<tr>
<th>Completely True</th>
<th>Very True</th>
<th>Somewhat True</th>
<th>True</th>
<th>Somewhat Untrue</th>
<th>Very Untrue</th>
<th>Completely Untrue</th>
</tr>
</thead>
</table>

1. I enjoyed using the system very much.
2. I think I am pretty good at using the system.
3. I put a lot of effort into learning how to use the system.

4. I did not feel nervous at all while using the system.

5. I think that the system is useful for managing my health from home.

6. I thought the system was boring.

7. After working with the system for a while, I felt pretty competent.

8. It was important to me to learn how to use the system well.

9. I felt very tense while using the system.

10. I think it is important to use the system because it can help me to become more involved with my healthcare.

11. I would describe the system as very interesting.

12. I couldn’t do very well with the system.

13. I didn’t put much energy into using the system.

14. I was anxious while interacting with the system.

15. I would be willing to use the system again because it has some value to me.

**E.2.2.3. System Usability (SUS)**

Instruction: Please rate the following statements based on this scale:

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Moderately Disagree</th>
</tr>
</thead>
</table>

1. I think that I would like to use this system frequently.

2. I found the system unnecessarily complex.

3. I thought the system was easy to use.

4. I think that I would need the support of a technical person to be able to use this system.

5. I found the various functions in this system were well integrated.

6. I thought there was too much inconsistency in this system.
7. I would imagine that most people would learn to use this system very quickly.

8. I found the system very cumbersome to use.

9. I felt very confident using the system.

10. I needed to learn a lot of things before I could get going with this system.

**E.2.2.4. General Opinion (Open-ended questions)**

1. Please name other functionalities you would like to see in the system.

2. State two things you like most about Healthcare4Life.

3. State two things you dislike most about Healthcare4Life.

4. Do you have any additional comments?

**E.2.3. Final Questionnaire**

The final questionnaire consisted of three pages. The first page contained structured questions related to HC4L and web-based health systems in general. On the second, users had to rate the usefulness of the features provided in HC4L. The third page gathered general opinion/suggestions on improving the system. An “N/A” (not applicable) response was included in this questionnaire allowing participants who did not use the system to share their comments.

**E.2.3.1. User Experience**

Instruction: Please rate the following statements based on this scale. Use N/A only if you have not used the system.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Moderately Agree</th>
<th>Slightly Agree</th>
<th>Slightly Disagree</th>
<th>Moderately Disagree</th>
<th>Strongly Disagree</th>
<th>N/A</th>
</tr>
</thead>
</table>

1. I would use Healthcare4Life if there were more applications.

2. A system like Healthcare4Life that provides access to a variety of health applications will reduce the need in using different websites for managing health.

3. Involvement of friends helped me to better manage my health through Healthcare4Life.
4. I would rather manage my health by myself, without anybody’s involvement in Healthcare4Life.

5. The social features of Healthcare4Life (e.g. making friends, sharing activity updates with each other, playing social games, etc.) motivate me to use the system.

6. The charts/graphs presented in Healthcare4Life helped me to understand my health progress better.

7. Healthcare4Life has the potential to positively impact my life.

8. Healthcare4Life simplifies health monitoring tasks that I found cumbersome to do before.

9. Healthcare4Life encourages me to be more aware of my health.

10. Healthcare4Life has the potential to help seniors in dealing with social isolation.

11. Healthcare4Life allows me to get in touch with other patients with similar disease or health problem.

**E.2.3.2. System Features**

Please rate the usefulness of the following features provided in Healthcare4Life. Use N/A only if you have not used the system.

<table>
<thead>
<tr>
<th>Very Useful</th>
<th>Fairly Useful</th>
<th>Somewhat Useful</th>
<th>Of Very Little Use</th>
<th>Not Useful At All</th>
<th>N/A</th>
</tr>
</thead>
</table>

1. Share/receive activities updates
2. Healthcare4Life Score
3. Add and remove health applications
4. Multiplayer Memory Game
5. Calorie Calculator
6. Weight Tracker
7. Exercise Tracker
8. Vitals Tracker
E.2 Evaluation Questionnaires

9. Send a Mail

10. Add/remove Friends

11. Search for Friends

12. Invite others to join Healthcare4Life

13. Perform/view application ratings

E.2.3.3. General Opinion (Open-ended questions)

1. Which feature of Healthcare4Life did you enjoy most?

2. Which feature of Healthcare4Life did you NOT like?

3. What other support, features or applications were you looking for that were not found on Healthcare4Life?

4. If you have not used Healthcare4Life regularly (more than 3 times a week), what are the main reasons for this?

5. Do you have any suggestions on improving the user interface of the system? (e.g. layout, button size, ambiguous labelling, colour scheme, navigation etc.)

6. With whom would you prefer to share your activities/information in the system?
   [ ] Family members
   [ ] Close friends
   [ ] Friends in Healthcare4Life
   [ ] Everyone in Healthcare4Life
   [ ] Myself only

7. Do you have any suggestions on improving the social features of Healthcare4Life? (e.g. making friends, sharing activity updates with each other, playing social games, etc.)

8. Would you continue using the system after this study?
   [ ] Yes
   [ ] No

9. Do you have any suggestions about how we could run these tests better in the future, either in terms of scheduling or in the way we ran it?
E.3. Responses to Final Open-ended Questions

Question: State 2 things you like most about Healthcare4Life.

<table>
<thead>
<tr>
<th>Participant ID</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP16</td>
<td>The memory game is good as it stimulates the brain to remember things. The other health applications is a great help to keep track of ones health.</td>
</tr>
<tr>
<td>SP34</td>
<td>It is simple to understand and the applications are interesting.</td>
</tr>
<tr>
<td>SP30</td>
<td>It showed that I do plenty of exercise and it showed that my weight was okay.</td>
</tr>
<tr>
<td>SP10</td>
<td>I like the ability to monitor and check your weight, vitals and what exercise you had been doing on a daily basis.</td>
</tr>
<tr>
<td>SP29</td>
<td>Ability to easily access.</td>
</tr>
<tr>
<td>SP5</td>
<td>Overview of the month results and tracking results.</td>
</tr>
<tr>
<td>SP6</td>
<td>The format was clear.</td>
</tr>
<tr>
<td>SP32</td>
<td>It’s easy to use.</td>
</tr>
<tr>
<td>SP1</td>
<td>I like the idea of it, obviously if you are thinking about your health and regularly checking it your health would improve.</td>
</tr>
<tr>
<td>SP27</td>
<td>Interaction with others and facility for record keeping.</td>
</tr>
<tr>
<td>SP17</td>
<td>I like the idea but it needs more development.</td>
</tr>
<tr>
<td>SP7</td>
<td>Keep track of weight and keep track of exercise needed.</td>
</tr>
<tr>
<td>SP15</td>
<td>Simplicity.</td>
</tr>
<tr>
<td>SP19</td>
<td>If I didn’t have other ways of tracking my weight loss, this might be useful.</td>
</tr>
<tr>
<td>SP37</td>
<td>Easy to navigate and the large font sizes.</td>
</tr>
</tbody>
</table>
**Question:** State 2 things you dislike most about Healthcare4Life.

<table>
<thead>
<tr>
<th>Participant ID</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP30</td>
<td>I would not share my medical details with someone I don’t know. I would like to be able to do memory games without having to play with someone I don’t know. Having to divulge my medical details to people I don’t know. Having to contact someone I don’t know in order to play the memory games.</td>
</tr>
<tr>
<td>SP43</td>
<td>Nothing.</td>
</tr>
<tr>
<td>SP10</td>
<td>Having to interact with others to get my percentage up even though I was exercising regularly and eating correctly.</td>
</tr>
<tr>
<td>SP5</td>
<td>Expand the sugar level for those who do not have normal levels.</td>
</tr>
<tr>
<td>SP6</td>
<td>The calorie counter. I had no idea how many of them I consumed per day. Blood pressure I do not take my own and as it is usually low am not concerned about it.</td>
</tr>
<tr>
<td>SP16</td>
<td>I think I don’t have any dislikes really. I do not eat anything on the breakfast list, I have the same thing 7 days a week so found having to enter this over and over too hard. Finding the calories for things not on the list too difficult. It’s too American.</td>
</tr>
<tr>
<td>SP11</td>
<td>It’s lack of development frustrated me.</td>
</tr>
<tr>
<td>SP19</td>
<td>There’s no interaction with other people. I can’t support others because I don’t know what their goals are.</td>
</tr>
<tr>
<td>SP32</td>
<td>I do not think I get any benefit from spending the time on it. At present there is not enough to do but I presume this will be different in future. It is hard to get the screen you want as they seem to overlap, eg contacting others / friends.</td>
</tr>
<tr>
<td>SP27</td>
<td>Limited applications and it needs more development.</td>
</tr>
</tbody>
</table>
Question: Do you have any additional comments?

<table>
<thead>
<tr>
<th>Participant ID</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP18</td>
<td>It did not inspire me enough to really get stuck into it. I don’t know why. It might be because once at home you don’t have much interaction, and I am a bit weary of using this kind of programs, unless I know it could help other people.</td>
</tr>
<tr>
<td>SP39</td>
<td>I think as a medical person in a medical family that I did not need to use it. I have an enquiring mind and use contacts and the internet to help me with health issues. However for people who do not have these interests I believe it can be very useful to them. Keep up the good work.</td>
</tr>
<tr>
<td>SP30</td>
<td>It was okay to start with but I wouldn’t want to use it on a continual basis.</td>
</tr>
<tr>
<td>SP10</td>
<td>It makes you stop and think about what you are doing and helps to moderate behaviour. You can’t have bacon and eggs for breakfast as they do not show on the calories list and if you add it how do you know what calories they have?</td>
</tr>
<tr>
<td>SP5</td>
<td>It is a good idea that needs smoothing out, because it has very limited programs at this stage.</td>
</tr>
<tr>
<td>SP11</td>
<td>If my circumstances hadn’t unexpectedly and suddenly changed I would have been interested in pursuing this, but would have been frustrated as I couldn’t show particular activities that I did. If that was corrected I would be interested in participating in any future studies.</td>
</tr>
<tr>
<td>SP21</td>
<td>I’m trying to come to terms with the concept of using the computer.</td>
</tr>
<tr>
<td>SP6</td>
<td>I think your categories are limited to people who have a specific range of illnesses. I could see no advantage in monitoring these areas as they are not a problem to me. I never did play any games. Possibly someway of encouraging folk to keep up exercise, but include hanging out, washing, etc.</td>
</tr>
<tr>
<td>SP1</td>
<td>Unless you have the gear the blood section is not possible apart from the resting heart rate.</td>
</tr>
<tr>
<td>SP27</td>
<td>I hope this programme will become more useful as time goes on and more people use it. I can visualise this in the future.”</td>
</tr>
<tr>
<td>SP15</td>
<td>The only way I could add anything to the “Vitals Tracker” was using an app on my iPhone. Anyone without this would only be able to add any details if they went to a doctor and asked for a reading.</td>
</tr>
<tr>
<td>SP19</td>
<td>There doesn’t seem to be anywhere that indicates how many Kcal I’ve used each day compared to the goal given to me. I have to add up the points on the graph. The list of foods is very American.</td>
</tr>
<tr>
<td>SP37</td>
<td>I probably haven’t tried hard enough with the system. Addition of other apps might make the system more attractive and useful. I’m not so keen on the “social” Facebook-like aspects of the system.</td>
</tr>
<tr>
<td>SP11</td>
<td>Not really, though I would like to see it broader based.</td>
</tr>
<tr>
<td>SP4</td>
<td>For elderly people to improve their quality of life as they age, a positive attitude is essential for well-being. Interaction with others in similar circumstances goes a long way in achieving this.</td>
</tr>
</tbody>
</table>
The following user guide was provided to participants of the final evaluation.
User Guide

This document provides step-by-step instructions on learning the basic features of Healthcare4Life. It is written exclusively for study participants to obtain some hands-on experience in using the system.

For any queries or information, please contact:

**Jaspaljeet Singh Dhillon**  
(PhD Student, The University of Auckland)

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Mobile: 021 859522  
Phone: 093681901  
Skype: jaspaljeet

June 2012 / V2.0
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</tbody>
</table>
A. Go to the Website

1. Open your web browser and type www.healthcare4life.com in the address bar. You will see the following homepage.

![Healthcare4Life Website](image)

*NOTE* The website works well on any browser, yet it looks best on Google Chrome and Mozilla Firefox.
B. Sign Up

1. Click **JOIN FOR FREE** to open the sign-up page.

2. For **username**, use a simple name to identify yourself in the system that you can remember when logging in next time.

   Use a short name to identify yourself in the system. It is recommended that you do not use spaces or any special characters.

3. Usernames are supposed to be unique. This will be indicated by the sign on the right side of the input box.

   - ✔️ The username entered is available.
   - ✖️ The username entered is unavailable. You need to choose a different username.

4. Fill in all other details requested on the page.

   **NOTE** Remember to take note of your **username** and **password**. You will need to enter this information to log into the system in the future.

5. Read the Terms and Conditions before clicking on **Get Started**.

   You will see a page with the following icons, which is the main menu of the system.
C. Create Profile

1. Click **Profile** on the main menu to open your **Profile** page.

2. Click **Edit Profile** to add more information to your profile.

3. Add your first name and last name. Other details can be added later.

4. If you are experiencing any health issue(s), select them from the list. You can add other diseases or health conditions in the **Other Issues** input box.

5. You can specify the email address of your family member or caregiver. An email will be sent to the address provided enabling them to monitor your progress on Healthcare4Life.

6. Click **Save Changes**.
D. Change Settings

1. Click Settings on the main menu to open your Settings page.

You will see a list of links that allow you to make changes to your account settings.

2. Click Profile privacy settings to make changes to your privacy settings.

3. From the drop-down list, select your preferred option.

4. Click Save Changes.
E. Search and Add Friends

1. Click Friends on the main menu to open your Friends page.

   ![FRIENDS](image)  
   All your friends in the system will be listed on this page.

2. Click Add More to open the Member Search page.

   ![ADD MORE](image)  
   You will see all registered members of Healthcare4Life listed on this page.

   **NOTE** You can view the profile page of the listed members by clicking on the profile picture. What you will see on the profile page depends on the privacy settings the user has chosen.

3. You can invite your friends to join Healthcare4Life by clicking Invite Friends.

   ![INVITE FRIENDS](image)  

4. Type jaspal in the Username/Email input box and click Search.

   You will see that Jaspal’s basic information and profile photo will be displayed.
5. Click **Add as Friend** to open the *Send Friend Request* page.

You can choose to add a message along with your friend request.

6. Click **Submit** to send the friend request.

**NOTE** When you submit the request, *Jaspal* will see your friend request in his *Friends* page as shown below:

<table>
<thead>
<tr>
<th>From</th>
<th>Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>YourUsername</td>
<td>![User Profile] (Accept)</td>
</tr>
<tr>
<td>![User Profile]</td>
<td>![User Profile] (Decline)</td>
</tr>
</tbody>
</table>

You will see him in your *Friends* page once he accepts.

7. Try to find and make as many friends as possible in the system as well as invite your own friends to join you in the system. Managing your own health could be easier when you do it with friends.
F. Activities and Comments

1. Click Activities on the main menu to open your Activities page.

2. Post a message (e.g. why you joined this study) and then click Share.

You will notice that your message now appears on your Activities page. See sample below:

```
johnq I am interested in managing my health.
2 seconds ago
```

Write a comment...  SEND

NOTE Your friends can comment on your message as it will also appear on their Activities page. The thumb icon next to Send can be added to your message (for motivation or encouragement purpose).
G. Add Applications

1. Click **Health Apps** on the main menu to open the *My Health Applications* page.

2. Click **Add More** to view the *Applications Directory* page and you will see a list of health-related applications available in the system.

3. Add the following applications from the *Applications Directory* by clicking on the respective **Add It Now**.

   - Weight Tracker
   - Vitals Tracker
   - Exercise Tracker
   - Multiplayer Memory Game

4. Click **Health Apps** on the main menu and you will see the list of applications that you have just added.
H. App 1: Weight Tracker

1. Click **Start** below *Weight Tracker* to start the application.

   ![Weight Tracker]

   **Weight Tracker**
   
   ![Start][Remove]

   **NOTE** The **Remove** button can be used to remove the application from your page. You will be able to add the application again from the *Application Directory*.

2. Enter your current weight and click on either the *Kilogram* or *Pounds* check box.

   ![Kilograms (kg)]

3. Click **Save**.

   **NOTE** You can only enter weight once a day. You cannot change the weight in the input box after you click **Save**.

4. Click on the blue **Settings**, then add a goal weight and click **Save Changes**.

   ![Settings]

5. Click on **My Weight Graph** to view your weight graph.
As you enter more values in the future you will see a line graph like the one below.

6. Click on **Edit Inputs** to make changes to the entered weight.

You can change the values in the input box and they can be deleted by clicking the following button:

![Delete button](image)

Remember to click **Save Changes** after you make any changes.
7. Rate this application by clicking on the yellow stars placed at the bottom of the application page.

Rate this application by clicking on the stars: ★★★★★★

**NOTE** You can rate this application based on your own judgement and you can always rate it again the next time you log in. The average rating will be displayed on the Applications Directory.

![Weight Tracker](image)
The personal weight tracker allows you to set your goal weight and track your weight changes on an automatically generated graph. You can choose your preferred system of unit – kilograms (kg) or pounds (lbs) – and the graph will be plotted accordingly. You can edit previously entered values.

(2 ratings)

8. Click **Activities** on the main menu to see the activity update.

![Activity Update](image)

Apart from writing positive comments, you can use the thumb icon to encourage your friends to continue using the health applications.
I. App 2: Exercise Tracker

1. Click **Health Apps** on the main menu to open **My Health Applications** page.

2. Click **Start** below **Exercise Tracker** to start the application.

3. Enter your current weight and you will see the recommended number of kilocalories you need to burn in a week.

   ![Exercise Tracker](image)

   **Log your exercise (in minutes) for today: 20 May 2012**

<table>
<thead>
<tr>
<th>Enter current weight:</th>
<th>65 kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Your recommended energy expenditure per week:</td>
<td>910 kcal</td>
</tr>
</tbody>
</table>

   **NOTE** If you are using the **Weight Tracker**, the current weight will be taken from there. You are advised to update your current weight in this application so the estimated amount of kilocalories to be burned in a week is kept up to date.

4. Enter the duration of exercise (in minutes) that you do or intend to do today by clicking in the respective input boxes.

   E.g. Stretching: **15**

5. Click **Save**.

   **NOTE** You can easily add/edit values of previous days and weeks. To add/edit values of the previous week, click **Previous Week**.
6. Click **My Exercise Chart**.

**My Exercise Chart**

You will see two charts. The bar chart shows the amount of exercise you have performed for the week. Each exercise is indicated by a different colour. The line chart shows the corresponding amount of energy expenditure. See sample graph below:
7. You can rate this application by clicking on the yellow stars placed at the bottom of the page.

8. Click Activities on the main menu to view your Exercise score. Your Healthcare4Life score is derived from different applications in the system showing the performance percentage for the week to date. The exercise score is taken from the Exercise Tracker that you have just used.

<table>
<thead>
<tr>
<th>Your Healthcare4Life Score (7 May 2012 - 13 May 2012)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memory performance</td>
</tr>
<tr>
<td>Vitals score</td>
</tr>
<tr>
<td>Exercise score</td>
</tr>
</tbody>
</table>

[NOTE] The ratio of the kilocalories you have burnt in the week to the figure that was suggested in the system is used to formulate the exercise score. This is a weekly score, so it will display the average exercise score for the week.
J. App 3: Vitals Tracker

1. Click Health Apps on the main menu to open My Health Applications page.

2. Click Start below Vitals Tracker to start the application.

3. Enter the vital data by clicking in the respective input box.

   E.g.

   Systolic blood pressure (mmHg) : 110  
   Diastolic blood pressure (mmHg) : 80  
   Resting heart rate (Beats Per Minute [BPM]) : 60  
   Fasting blood glucose (mmol/L) : 7

   [NOTE] You can leave the input box blank if you don’t have this information.

4. Click Save.

5. Click My Vitals Graph.

   You will see four graphs, each representing a particular vitals data. The graph will show if the entered vitals data is within the normal range. See sample graph below:
6. Rate this application if you like by clicking on the yellow stars placed at the bottom of the page.
7. Click **Activities** on the main menu to view your **Vitals score**.

![Image of Vitals Score]

**NOTE** The vitals score is calculated on how close you are to the normal range of the vitals. This is a weekly score, so if you enter vitals data regularly, the score will represent your vitals for the week better.
K. App 4: Multiplayer Memory Game

1. Click **Health Apps** on the main menu to open **My Health Applications** page.

2. Click **Start** below **Multiplayer Memory Game** to start the application.

3. Click **How to Play** to view the rules of the game.

4. Click **Play** to start the game.

   You will see a list of players available to play or who are currently playing the game.

   - **Challenge Now**: Both players get an individual score for the game.
   - **Play as a Team**: Both players share the same score.
   - **Busy playing**: The player is busy playing the game.

5. Click either **Challenge Now** or **Play as a Team** to play the game with anyone on the list.

6. Click on any two cards when your turn is indicated. The green box indicates that it is your turn.
You can continue clicking two more cards if you have found a matching pair.

7. Play the game until all the cards are face up.

[NOTE] You can click Cancel Game to stop at any time. Your score will ONLY be recorded if you finish the game.

8. Rate this application if you like by clicking on the yellow stars placed at the bottom of the page.

9. Click Activities on the main menu to view your Memory Performance score.

[NOTE] The memory performance score is calculated on the number of matching pairs of cards you have found and the total time you have taken to find them. This is a weekly score, so it will display the average memory performance score for the week.
L. Send Mail

1. Click **Mail** on main menu to open the **Mail** page.

![Mail Icon]

Your messages will be listed on this page.

2. Click **Send Message** to send a message to a friend within the HealthCare4Life network.

You will see a page containing the following input boxes: To, Subject and Message.

3. Type **jaspal** in the **To** input box.

**NOTE** To send a message to more than one recipient, separate the usernames using a comma (,).

4. Add a subject (e.g. Hi) and a message (e.g. I have some suggestions for you).

5. Click **Send Message** to send the message.

![Send Message Button]

A copy of the message will be available in your Mailbox.

6. Click **My Mailbox** to view the message.

**NOTE** New messages will be indicated with "new" in the subject.

<table>
<thead>
<tr>
<th>FROM</th>
<th>SUBJECT</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>sanggita, Jaspal</td>
<td>hi new</td>
<td>01/30/2012 - 19:21</td>
</tr>
</tbody>
</table>
M. Logout

1. Click **Logout** to leave the system safely.

---

*Thank you for your time and patience.*

*You have learnt how to use Healthcare4Life.*
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