An Online Social-Networking Enabled Telehealth System for Seniors – A Case Study

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Abstract

The past decade has seen healthcare costs rising faster than government expenditure in most developed countries. Various telehealth solutions have been proposed to make healthcare services more efficient and cost-effective. However, existing telehealth systems are focused on treating diseases instead of preventing them, suffer from high initial costs, lack extensibility, and do not address the social and psychological needs of patients. To address these shortcomings, we have employed a user-centred approach and leveraged Web 2.0 technologies to develop Healthcare4Life (HC4L), an online telehealth system targeted at seniors. In this paper, we report the results of a 6-week user study involving 43 seniors aged 60 and above. The results indicate that seniors welcome the opportunity of using online tools for managing their health, and that they are able to use such tools effectively. Functionalities should be tailored towards individual needs (health conditions). Users have strong opinions about the type of information they would like to submit and share. Social networking functionalities are desired, but should have a clear purpose such as social games or exchanging information, rather than broadcasting emotions and opinions. The study suggests that the system positively changes 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 positively affect their well-being.

Keywords: Telehealth, senior citizens, perceived ease-of-use, behavioural change, Web 2.0.

1 Introduction

Home telehealth systems enable health professionals to remotely perform clinical, educational or administrative tasks. The arguably most common application is the management of chronic diseases by remote monitoring. This application has been demonstrated to be able to achieve cost savings (Wade et al., 2010), and has been a focus of commercial development. Currently available commercial solutions concentrate on managing diseases rather than preventing them, and are typically standalone systems with limited functionality (Singh et al., 2010). They suffer from vendor lock-in, do not encourage patients to take preventive actions, and do not take into account patients' social and psychological needs.

In previous research, we argued that in order to significantly reduce healthcare cost, patient-centric systems are needed that empower patients. Users, especially seniors, should be able to manage their health independently instead of being passive recipients of treatments provided by doctors. Based on this, we presented a novel framework for a telehealth system, which is easily accessible, affordable and extendable by third-party developers (Singh et al., 2010; Dhillon et al., 2011b).

Recent research demonstrates that web-based delivery of healthcare interventions has become feasible (Lai et al., 2009). An Internet demographics trend from the Pew Research Center reports that more than 50% of seniors are online today (Zickuhr and Madden, 2012). Searching for health-related information is the third-most popular online activity for seniors, after email and online search in general (Zickuhr, 2010). In addition, Internet use by seniors helps to reduce the likelihood of depression (Cotton et al., 2012).

Web 2.0 technologies have the potential to develop sophisticated and effective health applications that could improve health outcomes and complement healthcare delivery (Dhillon et al., 2011a). For instance, PatientsLikeMe.com, a popular website with more than 150,000 registered patients and more than 1000 medical conditions, provides access to valuable medical information aggregated from a large number of patients experiencing similar diseases. According to Wicks et al. (2010), there is a range of benefits from sharing health data online including the potential of improving "disease self-management".

Most patient-focused social health networks offer a basic level of service, emotional support and information sharing, for a variety of medical conditions (Swan, 2009). However, most of these applications are expensive, do not offer a comprehensive suite of functionalities, target mostly younger health consumers, and do not replace traditional telehealth platforms (Dhillion et al., 2011a). A recent review of web-based tools for health management highlights that there is a lack of evidence about the effectiveness, usefulness and sustainability of such tools (Yu et al., 2012).

To address the aforementioned shortcomings, we have developed a novel web-based telehealth system, Healthcare4Life (HC4L), by involving seniors, its target users, from the outset (Dhillon et al., 2011b). Our focus is on seniors in general, which includes both people with

and without health problems. It is anticipated that the system will be useful to healthy individuals to maintain their health, while patients are assisted with monitoring and controlling their disease and with rehabilitation. A formative evaluation of a functional prototype of HC4L via a multi-method approach confirmed that seniors were satisfied with its usability, but further functionalities promoting exercises and supporting weight management were expected (Dhillon et al., 2012a). Results and feedback received from participants of the study were used to improve the final version of the system.

In this paper, we present a summative evaluation of an improved version of HC4L with a larger number of users. The goals of this study were to test the feasibility and acceptability of a web-based health management system with seniors. The secondary objectives were to assess the user satisfaction, effectiveness of the system, its content and user interface.

The rest of the paper is organised as follows. Section 2 provides a brief overview of HC4L. Section 3 presents the methodology used in the evaluation of the system. Section 4 presents the results which are discussed in Section 5. Finally, we conclude the paper in Section 6.

2 Overview of HC4L (Healthcare4Life)

2.1 Functionalities

HC4L is an extendable ubiquitous patient-centric system that combines the power of social networking with telehealth functionalities to enable patients, especially seniors, to manage their health independently from home (Singh et al., 2010). User requirements for the system were elicited from a group of seniors, details of which are presented in Dhillon et al. (2011b). The system was developed using Google's OpenSocial technology and the Drupal CMS (Dhillon et al., 2012b).

Similar to Facebook, the system has an open architecture that enables third-party providers to add new content and functionalities. It envisages hosting a variety of health-related applications which will be useful for health monitoring, education, rehabilitation and social support. Developers can design and deploy applications for these categories by using the OpenSocial standard, for example in the form of serious games, interactive web pages and expert systems.

HC4L encourages positive lifestyle changes by letting seniors manage their own healthcare goals. Patients are able to locate other patients suffering from similar diseases – enabling them to share experiences, motivate each other, and engage in health-related activities (e.g. exercises) via the health applications available in the system. The applications can be rated by the users thereby allowing the developers to get feedback. This is a crucial feature which allows users to get an indication of the quality and effectiveness of an application.

An important type of application is visualisations providing feedback and insight into health parameters. A growing body of evidence supports the illness cognition and behaviour processes delineated by the Common-Sense Model of self-regulation (Cameron and Leventhal, 2003; Hagger and Orbell, 2003). Visual representations allow patients to develop a sense of coherence or understanding of one's condition, and motivating adherence to treatment (Cameron and Chan 2008; Fischer et al. 2011).

Currently, we have developed and hosted several health monitoring applications, including a weight, vital signs and exercise tracker that records the data entered by the patients and gives visual feedback in the form of graphs and bar charts. We have also developed a social memory game that allows users to test their memory by finding matching pairs of cards. For motivation and feedback, all applications contribute to a general weekly score, which is presented to the user as an overall performance percentage.

At this stage, clinicians or healthcare experts are not included in the study. The idea is to empower consumers to manage their own care. However, the users are advised to contact their healthcare providers if unusual patterns in the monitored health indicators are detected.

2.2 User Interface Design

The user interface design process of HC4L contains two parts: design of the container (the system itself) and of the OpenSocial-based applications (health apps). The main design objectives were ease of use (easy to find

Figure 1: *Health Apps* page in HC4L

Section	Description
Activities	To share information about one's activities with the HC4L applications, view and comment on the activities of HC4L friends (allowing users to motivate friends with positive comments).
Health Apps	To access health applications added by third-party developers. Patients can add applications from the applications directory and remove them from their profile.
Profile	To enable patients to create an online health profile, which will enable other patients of similar interest or disease to locate them in the system. It also presents a summary of recent health applications used by the user.
Mail	To send mails to friends and other members in the HC4L network.
Friends	To access friends' profile page, find and add new friends, and invite others to join HC4L.
Settings	To change password and profile privacy settings, and to delete the user account.

Table 1: Main Functionalities of HC4L

content and to use functionalities), simplicity, and a visual attractive, consistent, and professional look (Dhillon et al., 2011). The user interface, as illustrated in Figure 1, contains a simple iconic horizontal menu at the top, which helps users to identify the key functionalities of the system. Table 1 provides an overview of the six main functionalities provided in the system.

A summative weekly health score is displayed at the top of the *Activities* pages, a page assumed to be frequently visited by the user. The score is emphasised using a large font size and a coloured box. The sub scores are shown as well, but using smaller fonts, to enable the user to identify which health parameters are satisfactory, and where more intervention (e.g. diet, exercises) is needed.

The system is equipped with a *Health Application Directory* (see Figure 1), which lists all applications developed and added by third-party providers. Each application is presented with an icon, a brief description of its use, average star ratings from users, and an "Add" button. Patients are required to click on the "Add More" button to open the directory, where they can add desired applications to their profile and remove them at any time, enabling them to customise the desired functionalities of the application. This customisation ensures a good balance between usability and functionality of the system. To use an application, the patient needs to click on the "Start" button or the respective icon, which will then run the application in canvas view.

The health applications in HC4L are created for common tasks such as tracking weight and physical activities. The applications were carefully designed with inexperienced users in mind and follow a linear structure. Each application has two to at most four screens. An example is the *Exercise Tracker* shown in Figure 2 and 3.

3 Methodology

3.1 Procedure

The study used a mixed method approach. The telehealth system was made accessible via the web using the domain Healthcare4Life.com. A 6-week live user evaluation of 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 senior community centres such as SeniorNet to advertise

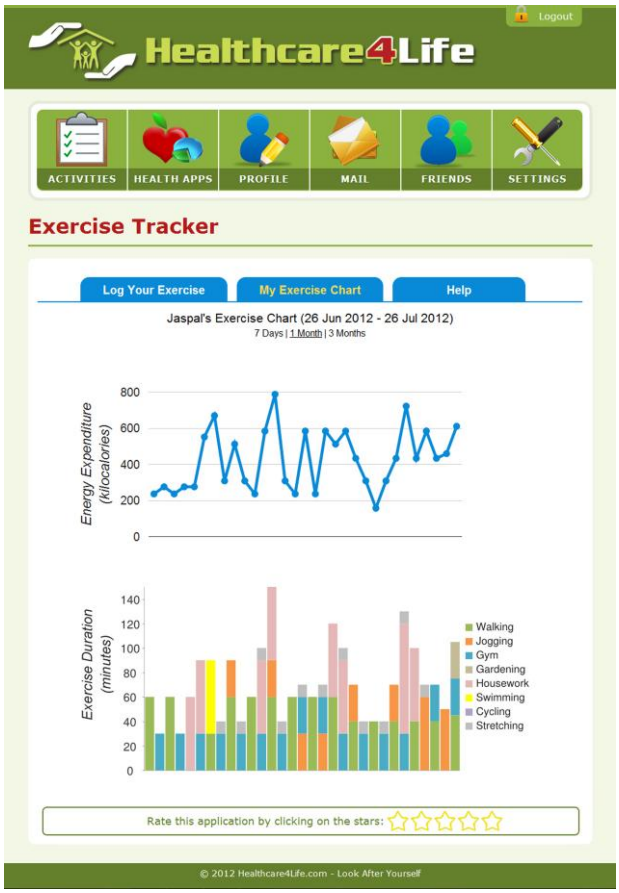

Figure 2: Visual feedback about exercise duration provided by the *Exercise Tracker*

Figure 3: Tabular interface of the *Exercise Tracker* for recording the user's physical activities

the study to their 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 began with a one-hour session comprising a system demo and basic explanations of how to use the system, which was offered on several days at the senior community centres. The objective was to provide an overview of HC4L, the user study, and of what was expected from the participants, and to create user accounts to access HC4L. A printed user guide 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.

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

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

Table 2: Content of questionnaire

Participants were encouraged to use the system at their own pace over a 6 week period. 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. Activities in the system were logged for later analysis. Reminders to use HC4L were provided via email once every week. Participants had to complete 3 online questionnaires at different stages of the study: after the initial meeting (initial questionnaire), at the end of the 3rd week (interim questionnaire) and at the end of the 6th week (final questionnaire). The content of the questionnaires with the number of participants that have completed them are provided in Table 2. At the end of the study, a short interview was conducted with four selected participants to gain further insights into their experience with and perceptions of HC4L. A NZ$40 supermarket voucher was given as a token of appreciation to participants that used the system continuously for 6 weeks.

3.2 Instrumentation

The questionnaires incorporated exisiting established scales as explained below: MHLC, IMI and SUS. In order to keep the questionnaire simple for the 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 Multidimensional Health Locus of Control (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. The scale comprises three subscales: "internal", "powerful others" and "chance" and has 18 items (6 items for each subscale).

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

Table 3: Subscales of MHLC and respective items (adapted from Wallston et al. (1978))

Following previous studies (Bennett et al., 1995; Baghaei et al., 2011), a shortened version of the scale was used, where 9 items (3 items for each subscale) were chosen from the original MHLC with 6 response choices, ranging from strongly disagree (1) to strongly agree (6) (see Table 3). The score of each MHLC subscale was calculated by adding the score contributions for each of the 3 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 and at the end of the 3rd week of the study. It was anticipated that the short duration of the study would not be sufficient to gauge behavioral change of seniors towards their health management. Therefore, we have examined the results as a signal of possible future behavioral change (Torning and Oinas- Kukkonen, 2009).

The Intrinsic Motivation Inventory (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 scale are available for use. The complete version comprises 7 subscales with 45 items, scored on a Likert-scale from strongly disagree (1) to strongly agree (7). We used a shortened version using 15 items (3 items for each of the 5 pre-selected subscales), which were randomly distributed in the

questionnaire (see Table 4). Items of the IMI scale as cited by McAuley et al. (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 8, 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.

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

Table 4: Subscales of IMI and respective items (adapted from IMI (2012))

User satisfaction with the system was measured using the System Usability Scale (SUS). This is a simple scale comprising 10 items rated on a 5-point Likert scale from strongly disagree (1) to strongly agree (5) that provides a global view of usability (Brooke, 1996). Table 5 lists the 10 questions of SUS. Participants' responses to the statements are calculated as a single score, ranging from 0 to 100, with a higher score indicating a better usability (Bangor et al., 2009).

Although SUS was originally designed to provide a general usability score (unidimensional) of the system being studied, recent research by Lewis and Sauro (2009) showed that it can also provide three more specific measures: overall system satisfaction, usability and learnability.

We have included additional Likert-type statements in the final survey, which were analysed quantitatively (see Table 9). 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 participant to express their opinions about certain aspects of the system.

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.

Table 5: The 10 items of SUS (from Brooke (1996))

4 Results

4.1 Socio-demographic Characteristics

The initial sample consisted of 43 seniors aged 60 to 85 (mean age 70, SD = 17.68). Most of the participants were female (62.79%) and European (81.40%). 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.

4.2 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 6 weeks. Although the study began with a larger sample, the user retention rate dropped over time (see Figure 4). This is in fact a common issue in live user studies (Baghaei et al., 2011). Fifteen participants

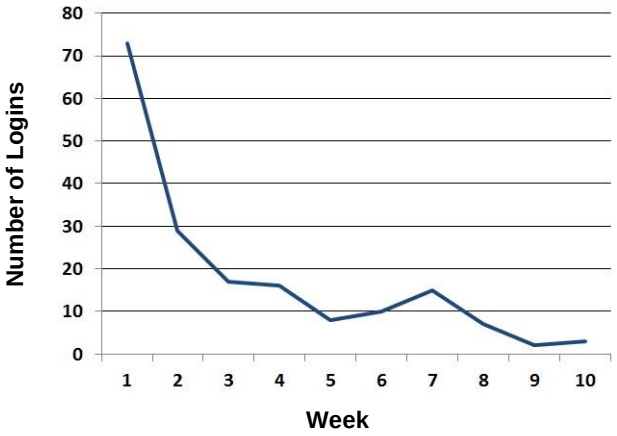

Figure 4: Participant retention rate

(34.88%) logged in only once. However, a few participants continued to use the system after the 6th week. It is interesting to note that the participant with the highest frequency of usage (25 logins) had very little experience with computers, and was very keen to learn how to use the system well.

Figure 5 depicts the overall usage of the 6 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 5 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%).

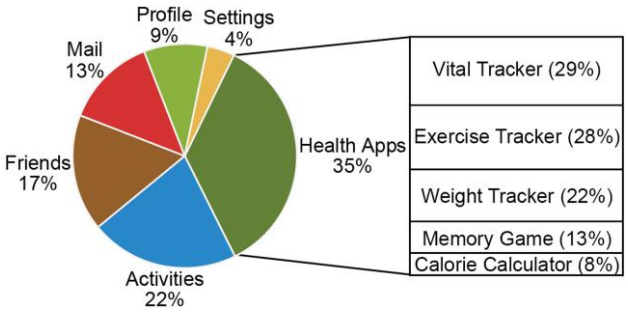

Figure 5: Participants' activities in HC4L

4.3 Change in Attitude

Table 6 reports the mean change scores for those participants who completed both the intial and interim MHLC questionnaires. Change scores for each MHLC subscale were calculated by subtracting baseline scores from follow-up scores.

The findings show that there were some improvements on all the three subscales. Participants responses for "powerful others", which denotes health is controlled by others such as doctors, reduced significantly by -.29. This suggests that the use of HC4L can reduce participants' reliance on others, such as health professionals.

Subscale	M	SD	Range
Internal	.04	1.04	-4 to 2
Powerful others	-.29	1.27	-10 to 6
Chance	-.10	1.23	-6 to 5

Table 6: Change in MHLC subscales (n = 23)

4.4 Motivation

Table 7 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 - 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/usefullness. Seniors of age range 60-69 consider themselves more competent and find the system more valuable than older seniors.

Subscale	All (n = 24)	Age 60-69 (n = 12)	Age 70-85 (n = 12)
Interest/Enjoyment	4.40 ± 1.68	4.42 ± 1.73	4.39 ± 1.70
Perceived Competence	4.39 ± 1.78	4.89 ± 1.52	3.89 ± 1.94
Effort/Importance	4.11 ± 1.58	4.11 ± 1.57	4.11 ± 1.56
Pressure/Tension	2.61 ± 1.56	2.67 ± 1.45	2.56 ± 1.69
Value/Usefulness	4.25 ± 1.81	4.53 ± 1.83	3.97 ± 1.75

Table 7: Subscale findings of the IMI (M ± SD)

4.5 User Satisfaction and Acceptability

Participants rated the usability of the system positively. Twenty-four users completed the SUS scale with scores ranging between 35 and 100, with a median of 65. The average SUS score is 68.33, with only two participants rating it below 50% (not acceptable). 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 to gain insight into their perception of HC4L. The most frequent positive and negative comments are listed in Table 8.

Table 9 presents the participants' mean responses for additional items included in the final survey of the study, with 6 response choices ranging from strongly disagree (1) to strongly agree (6).

Positive Responses	Frequency (%)
I like the idea of it.	26%
It is easy to use.	23%
The health applications are a great help to keep track of one's health.	16%
Negative Responses	**Frequency (%)**
Sorting out calories values for foods seems a lot of trouble (Calorie Calculator).	21%
I'm not so keen on the social Facebook-like aspects of the system.	18%
Limited applications.	15%

Table 8: Most common positive and negative comments about HC4L

5 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.

No.	Statement	n	M	SD	% Agree*
1	HC4L encourages me to be better aware of my health.	15	4.27	1.44	80
2	The charts/graphs presented in HC4L helped me to understand my health progress better.	15	3.93	1.28	80
3	I would use HC4L if there were more applications.	18	4.17	1.47	72
4	A system like HC4L that provide access to a variety of health applications will reduce the need to use different websites for managing health.	18	3.89	1.78	72
5	HC4L has the potential to positively impact my life.	17	3.82	1.67	65
6	HC4L has the potential to help seniors to deal with social isolation.	18	3.94	1.35	61
7	I would rather manage my health by myself, without anybody's involvement in HC4L.	18	3.56	1.69	56
8	HC4L simplifies health monitoring tasks that I found cumbersome to do before.	16	3.06	1.57	56
9	HC4L allows me to get in touch with other patients with a similar disease or health problem.	15	3.6	1.45	53
10	The social features of HC4L (e.g. making friends, sharing activity updates with each other, playing social games, etc) motivated me to use the system.	15	2.6	1.45	33
11	Involvement of friends helped me to better manage my health through HC4L.	13	2.54	1.76	31

**Percent Agree (%) = Strongly Agree, Moderately Agree & Slightly Agree responses combined*

Table 9. Selected Likert-scale items from the final survey

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 sample (80%) acknowledged that the system allows them to be more aware of their health. One participant commentated: "*It makes you stop and think about what you are doing and helps to moderate behaviour.*"

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 for managing their health. One of the participants 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 5).

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*", "*the foods are mostly Americ*an*"*, and "*it is not clear where to enter the data*". 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*, shown in figure 6, 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 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: "*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. The limited content and customisation of the system is also likely to be a reason for the reduced retention rate of the participants (as depicted in Figure 4). Users can become bored and discouraged to look 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 (Dhillon et al., 2011a). Therefore, the elevation of selfcare solutions such as HC4L, which do not involve clinicians, might result in adverse effects on a patient's motivation to use such systems.

Figure 6: ***Multiplayer Memory Game***

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 for managing their health despite the absense 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 (Dhillon et al., 2012a), 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 was: "*For elderly people to improve their quality of life as they age, a positive attitude is essential for wellbeing. 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. This is likely to be the effect of engaging the participants to monitor their health progress, 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 (see Figure 2) to ensure they have done enough to improve or maintain their health. It was interesting to note that the majority of the participants (80%) endorsed that the charts/graphs presented in HC4L enabled them to understand their health progress better. 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 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 to use Facebook-like social features. This finding is consistent with the outcome of the formative evaluation of the system (Dhillon et al., 2012a). The Facebook-like comment feature was retained since 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 to share personal information with others. A typical comment was: "*I would not share my medical details with someone I don't know.*" Figure 7 summarises with whom the participants would share their activities/information in the system.

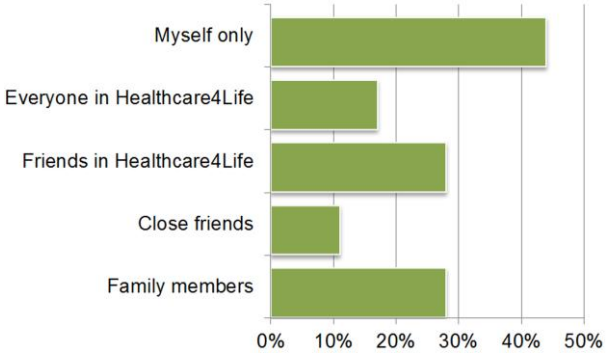

Figure 7: Participants' preference for sharing data about activities and other information in HC4L

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.*" While the comment sounds negative, it suggests that the participant wants to find new friends and get to know them more (i.e. to care about them and be cared about). This indicates that the social networking functionalities of HC4L are desired, but not in the form we might 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 to deal with social isolation. Nevertheless, it is necessary to revise the social component in a way which fosters building of 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. 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, like done in the website PatientsLikeMe.com (Wicks et al., 2010), since this gives users a sense of commonality and belonging.

6 Limitations

We recognize limitations of the study and avenues for future research. Most participants 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).

7 Conclusion

A web-based telehealth system targeted at seniors, which is extendable by third-parties and has social aspects, was developed and evaluated. A summative evaluation of the system was conducted with seniors over 6 weeks. Results indicate that the idea of using the web to manage health is well-accepted by seniors, but there should be a range of health applications which are tailored towards individual needs (health conditions). Social networking functionalities are desired, but not in the "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.

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