Designing a Mobile Pill Reminder for Elderly Users in South Africa

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Abstract

This paper discusses the design of a mobile pill reminder application for elderly users. Elderly people tend to forget to take pills and having an automated mechanism to remind them to take pills could be a major benefit to them. The My Pill Reminder application was developed for the Android platform and is very easy to learn and use. In addition to elderly people, it targets people who have little mobile experience and hence ease-of-use was a primary design goal. A preliminary user study was conducted to evaluate the usability of the application and to check if it met the users' expectations. The application had an average usability score of 89.4%, which indicates that the participants were highly satisfied with the application. Based on the results of the evaluation, several guidelines for designing mobile health applications for elderly users are proposed.

Keywords: mobile phone; medication compliance; usability evaluation; chronic disease; caregiver; Android platform, self-regulating system

Introduction

One of the major problems facing the world is providing effective healthcare. This problem is exacerbated in developing countries, which suffer from a lack of human and financial resources. There has been an increase in the number of people suffering from chronic diseases, which has been a burden to the community [16]. According to Sunyaev and Chornyi, chronic diseases place a huge load on the lives of a growing number of people and are largely responsible for the rising costs in healthcare [21]. Chronic diseases are difficult to deal with since they persist for a long time, implying that the user would need to seek medical attention for a long period. The National Centre for Health Statistics found in 2012 that 81.6% of elderly people have at least one chronic disease [1]. In order to minimize the effects of these diseases, users need to take pills on a daily basis [2]. Long-term conditions require attention on a daily basis because the goal is chronic disease management, which aims to reduce the disease burden of the condition [24]. This results in a need to investigate and explore efficient ways of helping users to take the right medicine at the right time. The *My Pill Reminder* application was developed to investigate how this problem can be solved by making use of mobile technology.

As age increases, it is usually associated with a reduction in the efficiency of the immune system, lessened and weakened hearing, diminished and a decline in eyesight and reduced mental or cognitive ability [3]. Effects of not adhering to a medication schedule and deviating from the schedule have proven to be severe and should be avoided as much as possible [4]. This implies that elderly people require some form of support mechanism in order to help them to adhere to their medication schedules. Typically, elderly people have caregivers, who are responsible for helping them in their daily activities including taking pills, but their number is significantly outweighed by the number of elderly people who needs care [5]. This implies that a self-regulating compliance mechanism would be useful in helping elderly people remember to take their pills. The self-regulating compliance mechanism will also help them to identify the pills that they ought to take as well as ensuring that the pills do not run out unexpectedly.

It is necessary to produce a solution that could be embedded within technology that many people are currently using. This would reduce the complication of users having to learn how to use new devices. According to recent studies, more than five billion people are using mobile phones of which approximately 170 million of these are elderly [6]. Research suggests that mobile phone solutions can play a major role in healthcare management [25]. Thus it is relevant to develop a mobile application to help elderly users with chronic disease management. Some work has been done in this field, but unfortunately this does not meet the needs of elderly users in South Africa. Some of these applications run on mobile phones like the Apple iPhone or the Windows Mobile platform, which are expensive in developing countries such as South Africa.

Related Work

There are several pill reminding systems that have been developed, but with different aims. However, not all of these systems were designed for elderly users. This

implies that most of the existing systems do not address the problems that were outlined in the previous section. This section reviews some related literature as well as some existing systems and mobile applications that were developed as possible solutions. The aspects that were considered important were the functionality supported, the user interface, the type of interaction as well as the general design and efficiency of the solutions.

A. Literature Review

According to World Health Organization, the threshold age to be considered elderly is sixty years [8]. As age increases, it is usually associated with a reduction in the efficiency of the immune system, lessened and weakened hearing, diminished and decline in eyesight, and reduced mental or cognitive ability [3]. Owing to this, elderly people face a lot of challenges in executing certain tasks in their every-day activities. One of the common conditions associated with this group is usually chronic diseases.

Chronic diseases are illnesses that are prolonged in duration, do not resolve spontaneously and are rarely cured completely [2]. Chronic diseases can be referred to as any diseases that tend to persist for a long time. According to National Centre for Health Statistics (NCHS), any period which is greater than three months is regarded as a long time [1]. Thus a chronic disease is one which persists for more than three months continuously. It is worth noting that these diseases tend to be more defined as age increases. There are different types of chronic diseases and they have different intensities, which require different levels of attention. Unlike acute illnesses that may be controlled with short-term intervention, chronic diseases require long-term management and monitoring, changes in lifestyle, and compliance to medication schedules [14]. Not all chronic patients need accommodation and aid offered by long term healthcare facilities. Some patients can be discharged to their homes and have their health conditions be monitored there [16]. It is only possible to discharge chronic patients to their homes if there is a mechanism to monitor their medication compliance. Studies done by the Health Research Institute shows that patients are willing to adopt mobile health monitoring and caregivers feel it would improve health monitoring and convenience [10].

Medication compliance refers to the degree or extent of conformity to the recommendations about day-to-day treatment by the provider with respect to the timing, dosage and frequency [15]. According to Morris & Schulz, medication compliance with short-term health conditions is generally considered to be higher than for long-term health conditions that require medication over a long period of time [27]. Medication compliance for chronic diseases is therefore low. Studies done by Liu, Zhu, Holroyd, and Seng suggest that medication compliance applications on the Apple App store are less than 5% of the mobile health applications available on the store [20]. This shows that mobile health initiatives aimed at improving medication compliance are lacking.

According to World Health Organization (WHO), less than 50% of patients suffering from chronic diseases in developing countries follow treatment schedules [7]. Some of the common reasons found for users not complying with their medication schedules include the following [7] [19]:

- Forgetting to take their medication;
- The user disregarding the doctor's instructions;
- Changes in the medication schedule;
- Unclear instructions which may cause confusion;
- A patient becoming overwhelmed by the number of pills to be taken;
- Fear of further complications and side effects;
- Assuming that the symptoms will vanish; and
- Stopping pill intake because the patient feels better.

Some of the reasons mentioned above are behavioral and are difficult to address in a mobile application. However, it is necessary that elderly patients have a mechanism to remind them to correctly take their pills as prescribed. Elderly patients with chronic diseases usually have caregivers looking after them. The major objective of caregivers is assisting elderly people in carrying out their daily activities and following their medication schedules. Due to the increase in the life expectancy and the number of elderly people suffering from chronic diseases, the number of caregivers is significantly less than that of the elderly dependency [17]. This shortfall gives rise to a need for a more personalized reminding mechanism, which will serve the same task as that provided by the caregivers. This mechanism could be in the form of a self-monitoring or self-regulating medication compliance system. A self-regulating medication compliance mechanism aims to enable the patient to comply with their medication schedule with minimized assistance from caregivers.

B. Existing systems

There are several systems that were developed to remind people to comply with their medication schedules using different forms of technologies and with different aims. These solutions have some similarities in the basic functionality provided but differ in terms of the functionality and the medium used for reminding the patient. A review was conducted to understand which of these systems is better with regards to support for pill reminders. The systems reviewed focused on improving medication compliance and the results were published in relevant literature. This review was based on the features and functionality of the different systems, results of the evaluation and the extent to which they cater for the elderly. Three systems were investigated namely: MedTracker, Real Time Medication Monitoring system

and Wedjat, which were developed for the Android platform.

Tamara, Hunt, Adami, and Kaye [18] developed a pillbox called MedTracker, which monitors medication adherence by extending the traditional seven-day pillbox. The device has compartments for holding pills for the seven days of the week and each compartment is loaded with the pills designated for that day by the patient. Data movement between the MedTracker and the computer is designed to be carried out through Bluetooth. The results indicated that it helped medication adherence, but could not help the patients in identifying the pills, especially for patients that took many pills at a time. The device is only operational if it is connected to a computer, which minimizes the portability of the device. MedTracker does not cater for elderly patients since some of the elderly struggled with loading the pills into the compartments.

Vervolet designed a system that uses Real Time Medication Monitoring (RTTM), an electronic dispenser and SMS reminders, to improve oral medication compliance for people with type 2 diabetes [22]. An SMS is sent when a patient forgets to take their medication and this is detected by an electronic dispenser. The results indicated that users were keen to adopt the technology since the patient only needs to use their mobile phones. The system is not intuitive and does not help the patient in identifying the pills. The system relies on the patient's interaction with the dispenser to detect if the patient took medication, which creates problems if the patient tries to interact with the dispenser at non-prescribed times. Operating such a system is expensive and receiving SMS'es would require the patient to manually delete them.

Wang, Tsai, Liu and Zao [23] proposed Wedjat as mobile solution to the problem of not taking pills properly and hence improving medication compliance. Wedjat was designed to run on the Android platform and uses reminders at the correct time, specifying the pills that need to be taken. The application is flexible but lacks visual cues to help the patients in identifying the pills to be taken. The application was designed not to take any action if the patient decides not to take their medication, which makes it unsuitable for patients with chronic diseases, who cannot afford to miss their medication. Wedjat only focuses on reminding the patient to take their medication and does not keep track of the quantity of the pills and provide alerts to re-order more pills. The application also does not have a history facility to show the level of the patient's medication compliance.

In addition, none of the three systems reviewed provide support for the South African context by incorporating a database with drugs used in South Africa.

C. Requirements

The reviews of the existing systems helped in generating requirements, which were used in the development of the *My Pill Reminder* application. The reviews also assisted in identifying good practices, which were used for the project as well as the negative aspects, which needed to be improved. To generate the requirements, interviews were carried out to investigate some of the problems that elderly patients with chronic diseases have in terms of medication compliance. Local medical practitioners, including pharmacists and doctors, were interviewed and the challenges they discussed together with the results found in the literature review were used to determine the requirements. Elderly patients with chronic diseases were not interviewed because ethical clearance was not obtained to conduct these interviews. The systems reviewed also identified that audible sound and vibration should be used to ensure that the chances of the user missing a reminder are minimized.

DESIGN

A. Data Design

The data for the application is stored locally on the mobile device of the user. Since the *My Pill Reminder* application was developed for Android, a SQL Lite database was used. *My Pill Reminder* will be deployed on mobile phones and therefore, it would be preferable to use a database that is not memory intensive. For this reason, SQL Lite was chosen due to the fact that it is a lightweight database which exhibits fast and efficient data retrieval.

B. Functional Design

The functionality supported by the *Mobile Pill Reminder* application was determined to be the following:

1. The system reminds the patient to take pills
2. The system notifies the caregiver(s) of a deviation in taking the pills
3. The system places an order when the pills are about to run out
4. The patient contacts a caregiver
5. The patient views pill details
6. The patient views upcoming reminders
7. The patient adds/remove pills to a reminder
8. The patient edits upcoming reminders
9. The patient views his/her history
10. The caregiver loads a prescription from the Pills database
11. The caregiver manages pills and dosage
12. The caregiver edits pills and dosage details
13. The caregiver deletes a pill from the current pill list
14. The caregiver places an order to a pharmacy

C. User Interface Design

The user experience is influenced by the nature of the user interface with which the users interact. Since the application was developed to run on Android devices, the

user interface was designed using a set of Android design patterns [12]. In order to satisfy the intended group of users, it was also necessary to consider the design guidelines for elderly and novice users. The final layout of the interface was developed using a combination of the Android design patterns and design guidelines for elderly and novice users. *My Pill Reminder* uses icons, which can be easily recognized by the users [12]. Since elderly people face challenges of visual and mobility impairments, which can affect their hand-eye coordination, the user interface design uses large icons which increase visibility and accessibility [9].

Figure 1. Home screen and its relationship with main screens

The user interface was designed in such a way that from the Home screen, there is direct access to the other key screens. The Home screen uses a dashboard layout with four icons which navigates to the key screens as shown in Figure 1.

Figure 1 illustrates the following design features:

- **Navigation:** from the Home screen, it is easy to navigate to other screens by clicking on the icons. The screens were also designed to provide an easy way to navigate to the Home screen by having a Home icon.
- **Consistency:** the screens were designed to have the same look and feel and help the user to easily learn how to use the application.
- **Visibility:** the screens have large icons, large text and different colors to make the content easily visible. Within the screens, icons were placed in predefined positions, which make them easy to see especially on the Action bar.

Figure 2 illustrates the steps followed by the user when the pills are taken. The user can choose to use the visual cues to help them to identify the correct pills. The Reminder screen also gives feedback to indicate pills which have been taken and those which have not been taken.

Figure 2. Reminder screen and taking a pill

The application was designed to minimize text input via the keyboard in order to facilitate text entry and minimize errors. Alternative input methods were used such as choosing from a list and using buttons to increase and/or decrease numbers. Figure 3 illustrates an example where the user can enter a number by using buttons as an alternative to entering the number.

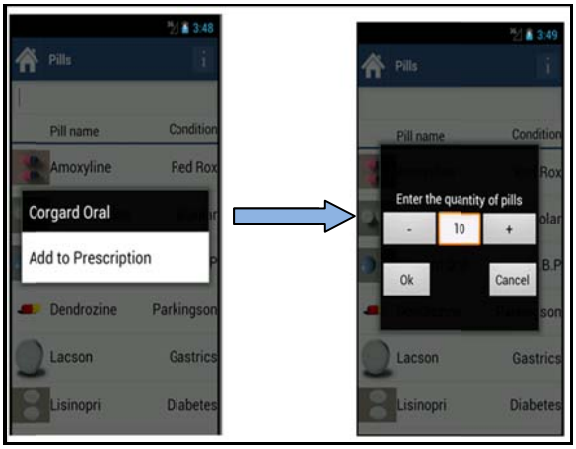


Figure 3. Example of flexibility in text input

EVALUATION

A preliminary user study was conducted to identify the extent to which the *My Pill Reminder* application is usable and if it provides its users with a pleasant user experience. The major purpose of conducting the

preliminary user study was to investigate the benefits that an elderly user could obtain from using the *My Pill Reminder* application as well as investigating the extent to which it is usable.

A. Objectives

The objectives of the preliminary user study were to determine the following:

- The usefulness of the application based on the feedback given by the users after using it;
- The extent to which the users could easily complete their tasks;
- The extent to which the application was intuitive to the user;
- The level of user experience and utility derived from using the application;
- Any weaknesses and strengths of the application; and
- Any changes that should be made based on the results of the usability study.

B. Metrics

In order to identify the extent to which the *My Pill Reminder* application was usable, several usability metrics were collected and analyzed. These metrics were used to draw up conclusions, which were consistent with the overall goal of the study.

The metrics used in the usability study were:

- Number of errors made by the user during the use of the application;
- Time taken to complete certain tasks;
- Number of incorrect options selected and other user errors;
- Number of questions asked requesting help; and
- Whether or not a task was completed correctly.

At the end of the tasks, the participants were required to complete a standard user satisfaction questionnaire, requesting them to rate the usability of the application [13].

C. Method

The preliminary user study was conducted in a usability laboratory where participants were brought into the laboratory and asked to perform a set of tasks whilst their performance was being measured. The study used eighteen participants who were divided into two groups based on their age. One of the groups comprised participants aged less than forty years (Group 1) and the other one with participants older than forty (Group 2). Group 1 performed the tasks for an administrator whereas Group 2 performed tasks for patients. The tests were done with the *My Pill Reminder* application running on a Samsung Galaxy S 3G mobile phone whilst video-recording the evaluation. The participants were encouraged to use the Think-Aloud Evaluation technique to facilitate obtaining valuable data from what the participants were saying.

To reinforce the evaluation techniques, observation was used to note the behavior of the participants. The participants were allowed to ask questions whenever they faced a challenge in executing some tasks and a frequent question was regarded as a usability issue and noted. Before the start of the evaluation, the first author volunteered to give a small tutorial to those participants who were not familiar with Android patterns. However, the tutorial was done using another application (not *My Pill Reminder*), so as to prevent the learning effect. The following tasks were performed during the evaluation:

1. Displaying a specified caregiver's details
2. Editing a specified caregiver's details
3. Calling and messaging a specified caregiver
4. Displaying a specified pill's details
5. Refilling the order for a specified pill
6. Scheduling a specified pill to a specified reminder
7. Viewing an upcoming reminder and adding pills to a specified reminder group
8. Editing a specified upcoming reminder
9. Taking medication after a reminder is displayed

Post-test questionnaires were also used to gather user satisfaction feedback based on their experience. The usability questionnaire that was used was the Post-Study System Usability Questionnaire (PSSUQ) [13], because it is a standard instrument which is often used in similar user studies.

D. Demographics

Figure 4 shows the demographics of the participants used during the preliminary user study. Figure 4 indicates that 56% of the users were male participants and 44% were female. The gender was almost evenly distributed, although the number of male participants slightly outnumbered the females.

Figure 4 also shows that there were two major age groups, namely the 18-25 years group and the 41-60+ years group. This figure illustrates the proportions of the participants for the two types of tasks. The 41-60+ years group performed the patient tasks whereas the 18-40 years group performed the tasks for the caregivers.

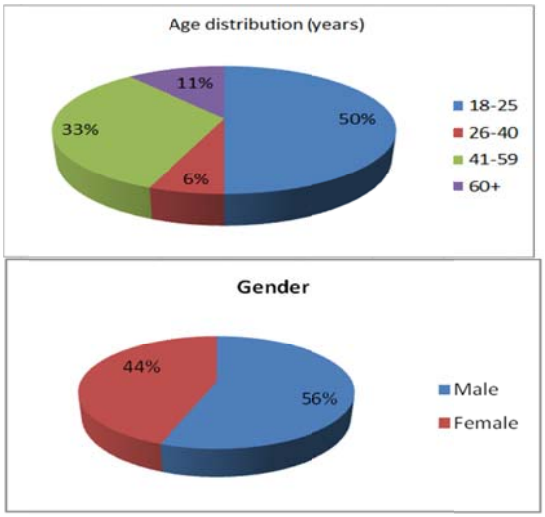
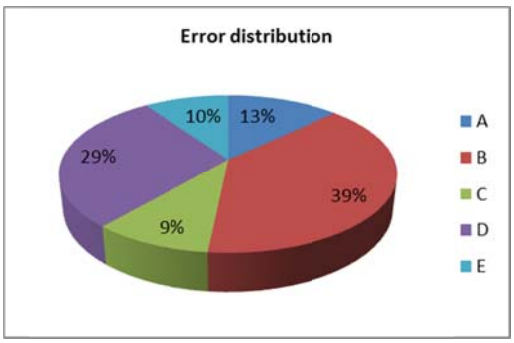


Figure 4. Demographics of participants (N=18)

Results and Discussion

A. Errors



Key

A	Pressing Back button more than once
B	Typing errors
C	Pressing the wrong Home button whilst on the administration screens
D	Clicking instead of using a long press
E	Forgetting to save

Figure 5. Distribution of errors by the participants (N=18)

There were several errors made by the participants during the evaluation process. Figure 5 shows the distribution of these errors and also classifies them into different categories. Most of these errors were as a result of those users who were not familiar with using an Android phone. The most serious error identified was when participants pressed the application's Home icon whilst attempting to navigate to the Administration Home screen instead of using the Back button.

B. Quantitative Metrics

Figure 6 shows the quantitative results obtained from the PSSUQ questionnaires. From the graph, it can be seen that all of the scores were above 80%, showing that the application was easy to learn, was regarded as useful, satisfied the users and performed well.

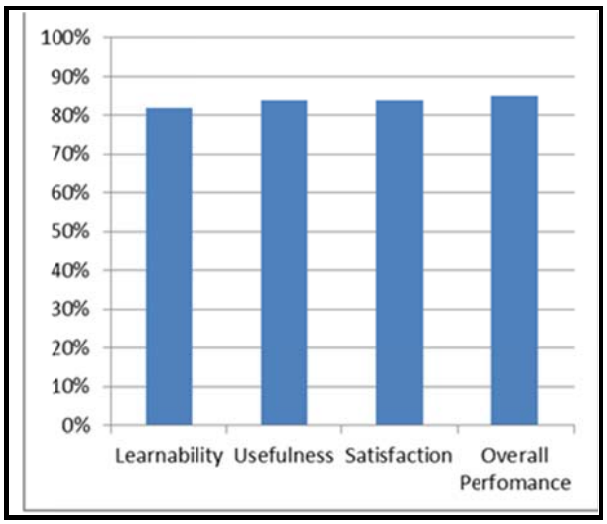


Figure 6. Graph illustrating the quantitative metrics and their mean scores (N=18)

C. Task Completion

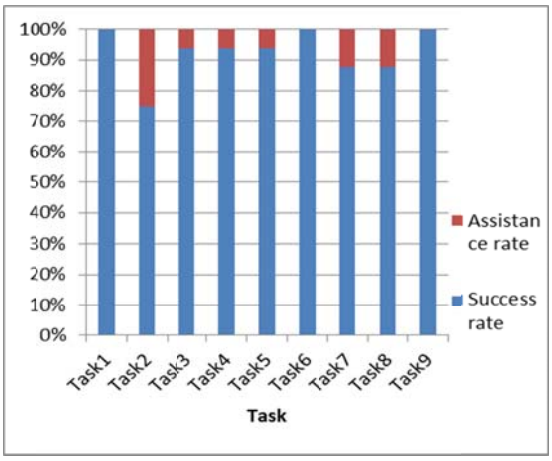


Figure 7. Graph for task success per task (N=18)

Figure 7 indicates that the participants managed to complete most of the tasks as is shown by the high level of task completion. The graph also shows the level of assistance offered to the participants whilst carrying out the tasks. The task success rates were very high and most of the participants managed to complete their tasks without any assistance. Figure 7 also shows that for some of the tasks (e.g. Task 2); the success rate was comparatively low. This was because some of the participants were not familiar with Android phones and

could not follow the Android patterns such as the use of contextual menus and hence sought assistance.

D. Overall usability of the application

Figure 8 outlines the overall usability scores from all the participants based on the selected usability metrics. The individual usability scores were converted to percentages. The means for all the participants were all above 85%, which indicates that the application had a high level of usability.

The metrics were assigned different weights based on the goals of the preliminary user study and the level of relevance of the metric related to the application's requirements. Learnability (25%) and satisfaction (25%) had higher weights since the evaluation focused mainly on finding out how easy it is to learn and the participants' perceptions towards the application. Usefulness was weighted 20% because the application was intended to have a positive impact on the elderly. Overall performance, efficiency and task success were weighted 10% each.

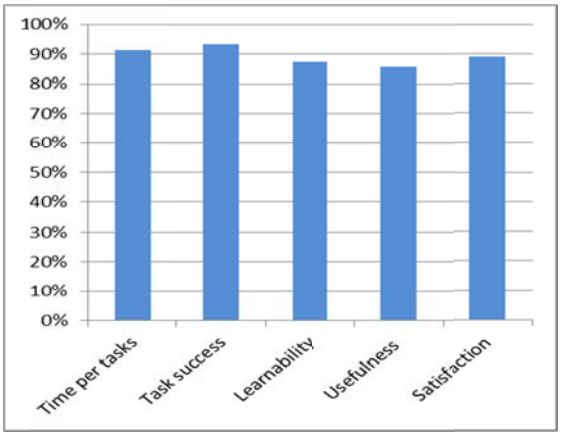


Figure 8. Graph illustrating the overall scores of the different usability metrics (N=18)

Based on the usability scores illustrated in Figure 8 and the corresponding weights, the overall usability score was calculated to be 89.4%, which shows that the participants managed to easily use the application and were also highly satisfied by it.

DESIGN IMPLICATIONS

The review of related systems discussed in the Related Work section, together with the Android design patterns and the guidelines for designing for elderly users discussed in the Design section were used to design the UI for the *My Pill Reminder* application. The key design principles were accessibility, ease of use, ease of learning, error prevention, flexibility, predictability and visibility.

The results of the evaluation were very good, showing that most of these design principles contributed to the high level of usability and satisfaction experienced by the users. Some minor design changes still need to be made to improve the learnability of the application, but all the mean scores were rated above 80%.

These design principles were translated into design guidelines for mobile health application for elderly users. These guidelines are described in Table 1 below.

Table 1: Guidelines for mobile health apps for the elderly

Functionality	Principle	Guideline
Text display	Accessibility, Visibility	Use large fonts, with visual cues and good color contrast.
Text entry	Error prevention, Flexibility	Use alternative text input methods, including options and lists.
Navigation	Consistency, Predictability	Use a simple navigation scheme, with minimal levels and clear icons. Include a Home icon.
Feedback	Visibility	Provide feedback on options selected and data entered.
Reminders	Ease of use	Provide audio and visual reminders.
Notification	Error prevention	Notify caregivers when patient fails to take medication.
Reordering medication	Ease of use Error prevention	Automate re-ordering of medication before it is needed.
History	Visibility	Provide a history of medication compliance for the patient.

CONCLUSIONS

The *My Pill Reminder* application was developed to support medication compliance among elderly users with chronic diseases in South Africa. The preliminary user study showed that the application met all of the expected requirements and provided a good user experience for its target audience. The design guidelines proposed in Table 1 could be used to develop similar mobile applications for elderly and novice users.

Using mobile health solutions to support medication compliance has the potential to increase in the near future. As the number of caregivers continues to be outnumbered by the number of elderly people suffering from chronic diseases, the importance of providing automated reminders using mobile phones becomes more important.

This study had several limitations. Firstly the preliminary user study used a small number of elderly participants, who didn't necessarily have chronic diseases. Secondly the user study was conducted in a single session, rather than over an extended period of time. Future work will include conducting a field study to determine the impact of using the *My Pill Reminder* application to support medication compliance among elderly users with chronic diseases in South Africa.

Acknowledgments

References

[1] National Centre for Health Statistics. 2012. Definition of Chronic Diseases [Online]. Available: http://www.medterms.com/script/main/art.asp?articlekey=33490 [Accessed: 03 April 2012].

[2] Australian Department of Health. 2010. Chronic Disease. [Online]. Available: http://www.health.gov.au/internet/main/publishing.nsf/content/chronic [Accessed: 03 April 2012].

[3] Salthouse, Timothy A. 2009. When does age-related cognitive decline begin?. Neurobiology of Aging 30 (4): 507–514, [Online]. Available: http://linkinghub.elsevier.com/retrieve/pii/S0197458009000219 [Accessed: 02 April 2012].

[4] Lorenz, A.; Oppermann, R. Mobile health monitoring for the elderly: Designing for diversity. Pervasive and Mobile Computing vol. 5 issue 5 October, 2009. p. 478-495

[5] Jing, G. and Koronios, A. 2010 Mobile Application Development for senior citizens [Online]. Available: http://www.pacis-net.org/file/2010/S05-03.pdf [Accessed: 03 April 2012].

[6] Butler, K., McDaniel, P. and Ongtang, M. 2010. Porscha: Policy Oriented Content Handling in Android. In ACSAC '10: Proceedings of the 26th Annual Computer Security Applications Conference ACM.

[7] Qudah, I.,Leijdekkers, P. and Gay, V. 2011. Using Mobile Phones to improve Medication Compliance and Awareness for Cardiac Patients. Life and Medical sciences – Health , [Online]. Available: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=555657 [Accessed: 03 April 2012].

[8] World Health Organisation (2012). Health statistics and health information systems –elderly people [Online]. Available: http://www.who.int/healthinfo/survey/ageingdefnolder/en/index.html [Accessed: 02 April 2012].

[9] Kurniawan, S., 2008, Older people and mobile phones: A multi-method investigation, Int.J. Human-Computer Studies 66, pp889-901

[10] World Health Organization.2013. Preventing chronic diseases: a vital investment. Geneva, World Health Organization. [Online]. Available: http://www.who.int/chp/chronic_disease_report/contents /part1.pdf. [Accessed: 11 January 2013].

[11] Shabtai, A.; Fledel, Y.; Kanonov, U.; Elovici, Y.; Dolev, S.; Glezer, C.; . (2010). Google android: A comprehensive security assessment. Security & Privacy, IEEE. 8 (2), 35-44.

[12] Beckley, A. 2011. Android design guidelines version 1.[Online]. Available:http://www.mutualmobile.com/wp-content/uploads/2011/03/MM_Android_Design_Guidelines.pdf [Accessed: 16 May 2012].

[13] Lewis, J. R. (1995). IBM computer usability satisfaction questionnaires: Psychometric evaluation and instructions for use. International Journal of Human–Computer Interaction, 7,57–78.

[14] Chen, G., Yan, B., Shin, M., Kotz, D., & Berkel, E. (2012). MPCS : Mobile-Phone Based Patient Compliance System for Chronic Illness Care.

[15] Cramer, J., Roy, A., Burrell, A., & Fairchild, C. (2008). Medication compliance and persistence: terminology and definitions. Value in Health, 11(1), 44–47. doi:10.1111/j.1524-4733.2007.00213.x

[16] Elgazzar, K., Aboelfotoh, M., Martin, P., & Hassanein, H. S. 2012. Ubiquitous Health Monitoring Using Mobile Web Services. Procedia Computer Science, 10, 332–339. doi:10.1016/j.procs.2012.06.044

[17] García-Sánchez, P., González, J., Mora, A. M., & Prieto, A. 2013. Deploying intelligent e-health services in a mobile gateway. Expert Systems with Applications, 40(4), 1231–1239. doi:10.1016/j.eswa.2012.08.068

[18] Hayes, T. L., Hunt, J. M., Adami, A., & Kaye, J. a. (2006). An electronic pillbox for continuous monitoring of medication adherence. Conference proceedings : IEEE Engineering in Medicine and Biology Society. Conference, 1, 6400–3. doi:10.1109/IEMBS.2006.260367

[19] Khan, D. U., Siek, K. a., Meyers, J., Haverhals, L. M., Cali, S., & Ross, S. E. 2010. Designing a personal health application for older adults to manage medications. Proceedings of the ACM International Conference on Health Informatics - IHI '10, 849. doi:10.1145/1882992.1883124

[20] Liu, C., Zhu, Q., Holroyd, K. a., & Seng, E. K. 2011. Status and trends of mobile-health applications for iOS devices: A developer's perspective. Journal of Systems and Software, 84(11), 2022–2033. doi:10.1016/j.jss.2011.06.049

[21] Sunyaev, A., & Chornyi, D. 2012. Supporting chronic disease care quality. Journal of Data and Information Quality, 3(2), 1–21. doi:10.1145/2184442.2184443

[22] Vervloet, M., Van Dijk, L., Santen-Reestman, J., Van Vlijmen, B., Van Wingerden, P., Bouvy, M. L., & De Bakker, D. H. 2012. SMS reminders improve adherence to oral medication in type 2 diabetes patients who are real time electronically monitored. International Journal of Medical Informatics, 81(9), 594–604. doi:10.1016/j.ijmedinf.2012.05.005

[23] Wang, M.-Y., Tsai, P. H., Liu, J. W. S., & Zao, J. K. 2009. Wedjat: A Mobile Phone Based Medicine In-take Reminder and Monitor. 2009 Ninth IEEE International Conference on Bioinformatics and BioEngineering, 423–430.

[24] Williams, L. 2012. Overcoming barriers to self-care, The Nurse Practitioner 37(3), 32–38

[25] Kinkade S, Verclas K. Wireless technology for social change. Washington, DC, and Berkshire, UK; 2008. [Online]. Available: http://mobileactive.org/files/MobilizingSocialChange_full.pdf, [Accessed 18 April 2013]

[26] Morris, L. S., & Schulz, R. M. 1992. Patient compliance-an overview, Journal of Clinical Pharmacy and Therapeutics (1992) 17,283-295.