An Integrated and Digitized Care Framework for Successful Aging

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Abstract— "Successful aging" or aging well is a very complex process. This process is usually defined as having the following components: managing chronic conditions, maintaining physical and mental health, social engagement. There exist many solutions in isolation for these individual components that assist in aging well. However, while these components in isolation can work, we believe that the real strength of these components is in their synergism–in their combined power to help seniors in aging well. We are developing a unified framework "eSeniorCare", which addresses all of these components together. It is a mobile platform that has the following features: medication scheduling, daily activity tracker. As a part of this framework, sessions are conducted to provide motivational lectures in aging. In this paper, we present the first phase of the framework.

I. INTRODUCTION

As early as 44 B.C., in the essay *De Senectute*, Cicero mentioned that old age is not a phase where people are in a state of loss. Rather, he argued that proper aging offers opportunities for positive change and productive functioning [1]. Traditionally, researchers have defined the absence of chronic conditions or disabilities as one of the main components of "successful aging" [2]. However, studies have shown that only a small percentage of the senior population have met this criterion [3], [4]. Moreover, chronic conditions are almost inevitable with old age [5]. So, researchers have re-defined the components of "successful aging" to include social engagement, cognitive ability (brain health), meaning of life, and physical health [6]. One important criterion for maintaining physical health or preventing functional

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impairment is the management of chronic conditions [7]. Hence, components of "successful aging" would include the management of chronic conditions, a maintenance of physical and cognitive health, and active social engagement.

A large percentage of the senior population suffers from multiple chronic conditions [8], [9]. These chronic conditions could be improved by taking medication as prescribed [10]. However, more than 50 percent do not adhere to the medications as per the medication regime [11]. Medication non-adherence affects an individual both physically and mentally. It also raises the health care costs by increasing the number of readmissions to the hospital [10], [12]. Hence, it is a growing area of concern. This concern will be furthered by the projected increase in the number of seniors. According to the Federal Interagency Forum on Aging-Related Statistics, is, by 2030, expected to be double what it was in 2000, as the "Baby Boomers" start turning 65 from 2011.

In order to detect diseases in their nascent stage for better treatment, a patient-centric preventative healthcare approach is being adopted. This approach also increases patient compliance, and reduce healthcare costs. It, also, empowers the patient in well-being [13]. As healthcare reforms continue to accelerate to use of technology [14], and with seniors becoming increasingly computer literate [15], technological solutions are poised to have an important role in improving the health and quality of life.

To improve quality of life, medication adherence and help aging successful, we have launched the program "eSeniorCare: A comprehensive digital solution for physical health, vitality, and brain fitness". The program has been started with the Aging in Place Program [16] and Memorial BrainWorks [17], Memorial Hospital, South Bend, Indiana. The purpose of this program is to examine how technology can benefit seniors and help them improve their health and quality of life. The program is also aimed at building technology for health services, which have a considerable impact on healthcare costs. This paper presents the results from the pilot (Phase 1) of the eSeniorCare implementation.

II. BACKGROUND

The Aging in Place Program [16] was started in 2006, in collaboration with the South Bend Heritage Foundation [18], a non-profit community development corporation. It helps low-income, older individuals (aged 55 and older) to remain independent and in their own homes for as long as possible, while increasing participants' quality of life through social support and community building. It now operates in three

subsidized facilities: Housing Authority of South Bend (non-profit, featuring 'Section 8' apartments) [19], the for-profit Heritage Place at LaSalle Square (part of a neighborhood redevelopment project) [20], and Robertson's Apartments. Each program location has two community health workers (CHW): a nurse, who assists the individuals in their medical needs, and a resident life administrator, who focuses on building community through social activities, community resource navigation, and connectivity. The "eSeniorCare" program is designed for Heritage Place at LaSalle Square. Established in 1988, Memorial BrainWorks[17] conducts the program "Heart of Aging with Wisdom and Vitality". It is a dynamic, interactive program that encourages people to engage older adults in ways that help them see the joys of aging, and to engage in activities and group discussions that create legacy, contribution, connection, and self-accountability.

III. RELATED WORK

Various direct and indirect measures have been implemented for monitoring medication adherence. Some of the direct methods include observed therapy, measurement of medication or metabolite in the blood, and measurement of biological markers in blood [21]. Indirect methods include patient questionnaires, self-reports, pill counts, rate of prescription refills, assessment of the patients' clinical response, electronic medication monitors, measurement of physiological markers, and patient diaries [21].

Though the direct methods are generally more accurate, the costs involved for these methods make them unfavorable options. On the other hand, the indirect methods have lower costs but rely heavily on patients' response. One of the disadvantages with pill counts is that it can generally be manipulated by discarding the remaining pills and taking the empty bottle to the pharmacy. This provides an overestimate for medication adherence. In contrast, electronic monitors record the opening and closing of the pill bottle [22]. They can provide an underestimate for medication adherence as some patients may use pill boxes to store their daily medications, instead of the actual pill bottle to which the electronic monitor is attached. Because of the above reasons, it is suggested to use one or more methods for monitoring medication adherence.

The increasing usage of smartphones has led to the emergence of prescription scheduling and adherence applications (apps). A popular feature within these apps is to provide daily medication reminders. Apps like MedCoach [23] provide visual alerts once a day, while, some apps like Dosecast [24], MedCoach have features that can automatically send refill reminders to the pharmacy. However, the prescriptions can be filled by multiple pharmacies. Moreover, a pharmacy might not have access to the reminders from the app as they may not be part of the app pharmacy network. A major issue with these apps is that the user has to enter his or her own medications. Generally speaking, the longer the list of medications to be entered, the more difficult it is for the seniors due to their old age. If they are provided with

some automated services for entering their medications, the apps would be more useful. However, in "eSeniorCare", the medications are entered by CHW, not by the seniors.

Medication adherence apps only concentrate on aspects related to one's medications, diagnoses, etc. and hence, do not provide any solution for daily activity tracking. Daily activity tracking is required for seniors to age well, maintain their mental and physical health. If one wants to track their daily activities, one has to use some other apps or devices like Fitbit.

IV. FRAMEWORK

Our approach provides a unified digital solution for senior care and well being. A smartphone-based healthcare application has been built which performs the following features:
- Observations of Daily Living
- Medication Scheduling and Management
- Medication Adherence Feedback
- CHW Integration

A. Observations of Daily Living

Observations about a person's everyday activities can be indicative of risks or trends in a person's health. Information on daily activities like exercise, diet, mood, and sleep patterns have an intrinsic relationship with one's health and can provide the clinicians with more useful information, and aid in decision making. As a part of this feature, the user will be asked to answer questions in the morning and in the evening. The morning questions pertain to their plans for the day, while the evening questions pertain to what they did that day. As shown in Figure 1, as part of their morning questions, the user can enter how long they plan to walk, while for evening, if they actually went for a walk. The users can schedule reminders for answering the morning and evening questions, as they might not remember to answer the questions.

B. Medication Scheduling and Management

To improve medication adherence, the application will help in prescription drug scheduling and provide daily medication reminders. The users will receive medication reminders 5 minutes before their prescribed dosage time. The reminder provides a list with the following information:
1) Medication name
2) Dosage information: quantity and unit
3) Audio: speaking out the name of the pill
4) Image of the pill
5) Check box to confirm the medication is taken: The participant will be confirm all the unchecked medications

A magnified image of the pill can help the users better identify the pill to be taken as in almost all the cases, people identify pills by their color, size, and shape rather than by their name. Figure 1 provides a sample reminder. The application will also provide a list of their past and current medications, along with their diagnoses and dosage information. The user can show these lists to the clinicians, which could help avoid duplicate prescription and aid in better prescription management.
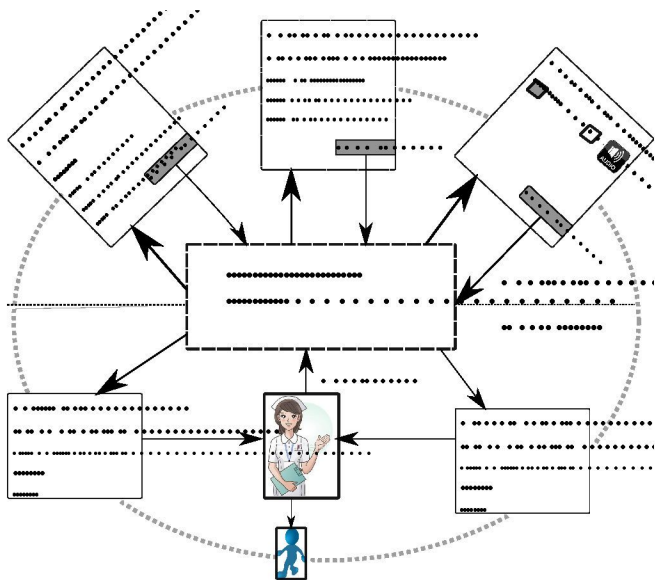
Fig. 1: Application Features

C. Medication Adherence Feedback & CHW Integration

Any missed medication is reported to the CHW via a web portal so that CHW can take the required action. Also, if any check box associated with a medication is not checked, the user has to confirm if the check box was not clicked by mistake. To validate these responses, the application will have a "Refill Medications" button. Upon clicking this button, a list of the user's refillable medications is provided. From this list, the user can select the ones for which they require a refill. If the calculated refill date does match with the requested date, the CHW will be notified through the portal. The "Refill Medications" feature is implemented to validate the response for medication reminders. This can be used as a proxy for medication adherence, as the calculated date is based on the pill count and the dosage. The updates will assist the CHW in tracking the progress of each member, thus ensuring continuity of care, monitoring, and adherence.

V. IMPLEMENTATION

We used Samsung Galaxy Tab 2 7.0 tablets for implementing our framework. According to the PEW Internet Survey, from 2012 to 2013, there has been almost a 10 percent increase in number of seniors (aged above 65) with tablet ownership [25]. The tablets provide a large screen with optional keyboard, and thus, are becoming more popular among the seniors [26].

If the target audience is not involved in the design process for developing applications, there is a high possibility of a huge gap between the developer's perspective and the target population's expectations [27], [28]. In order to meet the requirements and to improve the usability of applications for seniors, researchers have involved seniors in the design brainstorming sessions. Before the actual launch of the application, a group of 6 participants were chosen. On May

24, 2013, the tablet with a prototype of the application was given to these participants. They provided feedback on the features and usability of the application and the device.

A. Pilot Phase

For the pilot phase, 15 patients were selected from a total of 72 residents at Heritage Place, Lasalle Square. The participants were selected according to the following criteria:

- Diagnosed with at least one chronic condition
- Prescribed with at least one medication
- Passed the Saint Louis University Mental Status (SLUMS) Exam [29]
- Fluent in English

The participants signed consent forms from Memorial Hospital and the University of Notre Dame, provided by the Institutional Review Board (IRB). As per the IRB, the data on server has been completely de-identified. Also, the mapping of usernames for the application and the actual participants were maintained by Memorial Hospital.

An Android based application was developed with the following functionalities:

- Submit responses for morning and evening surveys
- Configure reminders for morning and evening surveys

Only the "Observations of Daily Living" component was implemented for the pilot phase in order to separately study the effects of each component of our approach on improving the quality of life for seniors.

A web portal was developed for updates on missed medications, reminder on refills thus ensuring continuity of care. It was also used for data entry via a HTTPS connection.

In addition to maintaining physical health, accepting aging is important for improving one's life. Thus, to provide motivational lectures on successful aging, Memorial BrainWorks conducts sessions on a total of 12 fields like Psychology, Neuroscience, etc, every other week. Following each session, the participants are asked to answer two knowledge questions related to the program they engaged in and are given the opportunity to share thoughts in response to an open-ended emotional question such that insights and new awareness' can be analyzed.

VI. CHALLENGES

One of the major challenges that we faced was lack of WiFi Connectivity. The implementation site only had WiFi access along the core of the building where the community gathering places like the community center, library, gym, and computer center are located. So, the application had to be designed in a manner that the WiFi is only required for synchronizing the server. As such, the application has a local database (part of the device internal storage) that stores the submitted answers and questions to be displayed. Additionally, this design promotes social engagement, as the participants have to come to the community gathering places for WiFi connectivity. This is important as studies have shown that one of the key elements for successful aging is social engagement [2], [30]. Seniors tend to isolate themselves in their houses primarily because of health conditions.

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The pilot program was launched on September 25, 2013. We conduct feedback sessions once every month. The participants have the option of raising concerns outside the sessions as well. On October 25, 2013, we conducted our first feedback session from the participants. The feedback provided a new dimension to the study. Every age group expresses different perspectives on the same issue. Some of the issues were regarding the interpretation of words used in the morning and evening questions. The following are some of the examples:

- One of the questions had the word "room" referring to the current residing place. The word "room" was replaced with "apartment" as the participants usually associate home with senior or nursing homes. The participants believe that "apartment" refers to an independent living facility.
- Another question related to their plans for the day included "play games" as one of the options for answers. "Games" was replaced with "board or card games" as playing "games" is perceived to be juvenile activity.
- Again, a few participants raised their concern against "go to gym for exercise" as an option because they thought the gym in the building to be an "exercise" room. They also prefer to exercise in their apartments.

VII. CONCLUSION

We have found that mobile applications can help seniors in managing their daily activities, social engagement, medication scheduling. The applications promote self-management and, hence, help the seniors to live independently. However, it is important to involve the target population (seniors) in the design, evaluation and implementation of the application, as we found that they provide perspectives beyond the imagination of a young person. It should be kept in mind that use of technology cannot completely eliminate human intervention for disease management, social interactions.
The the next phase will be the rollout of the application with "Medication Scheduling and Adherence". The main hypothesis for this feature is that if one knows their medications, diagnoses well, one will take their medications on time. After the evaluation of the outcomes of this study, the application will be launched in other facilities.

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