eSeniorCare: Technology for Promoting Well-Being of Older Adults in Independent Living Facilities

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***Abstract*—The aging population (seniors) maintains a strong desire to remain independent as long as possible while maintaining their physical health and emotional well-being. We have witnessed a growth in technological solutions delivered as Apps on mobile devices for health and wellness. However, several challenges remain in their application to assist seniors in the dimensions of health and wellness. They fail to provide sufficient connectivity and a level of usability that is appropriate for seniors. To that end, we are developing a tablet-based application, *eSeniorCare*, to integrate various components of health and well-being targeting successful aging. Our design and development followed an iterative process involving feedback from the participants. We conducted a 31-week study of the application with 16 participants at an independent facility in collaboration with Memorial Hospital of South Bend. Our study found that through the use of the application, participants demonstrated improved technological health management skills and decreased risk for depression, suggesting that *eSeniorCare* represents an important step toward improving senior care and quality of life.**

I. Introduction

Aging well, known more formally by researchers as "successful aging" [1], includes the maintenance of physical and mental health and continued, active social engagement [2], [3]. In general, members of the aging population (seniors) want to remain independent as long as possible while maintaining their physical functioning and emotional well-being [4] (dimensions of health that may be used to define an individual's health-related quality of life (HRQOL) [5]). Sustaining proper physical functioning entails the maintenance of robust physical health, and thus the cultivation and maintenance of a healthy lifestyle—to which there are many barriers and challenges.

Unfortunately, the complex set of behaviors involved in the maintenance of a healthy lifestyle and the management of chronic conditions can be challenging for the aging population [6], [7]. Strategies like self-monitoring and activity tracking can be used to address these challenges with some success [8]. However, the management of chronic conditions often results in medication non-adherence [9]–[11], a problem that can lead to dire physical effects and increased healthcare costs [7], [12], [13]. Poor physical health may also increase the risk for depression among seniors [14], [15]. It is therefore critical to develop a comprehensive framework to address the challenges associated with all of these components—the maintenance of physical health, medication non-adherence, and depression—to help seniors remain independent as long as possible.

Many smartphone and tablet-based applications exist for providing medication management [16], [17] and activity tracking [18]. Unfortunately, the vast majority of these applications do not address other dimensions of health. The majority of these applications are also designed for use by technologically proficient individuals and are not well-suited for use by seniors, who can be slow at adopting new technology [16]. Further, these applications have limited or no capacity to integrate with care providers, which can be instrumental in helping the care providers/clinicians to identify the root challenges in performing daily activities or in adhering to a medication regime [19]. And as the average life expectancy rises, remote communication between seniors and care providers is growing even more important, with a growing number of seniors competing for a limited number of care providers [20], [21].

We are developing a mobile platform, "*eSeniorCare*," designed specifically to help seniors maintain physical and emotional well-being and to promote communication between seniors and their care providers. The tablet-based application can help the seniors residing in independent living facilities to track their medications and monitor their daily activities. We have also developed a web portal that allows care providers to communicate with seniors regarding missed doses, changes in medication, and medication refills. In this work, we evaluate the usability and effectiveness of *eSeniorCare* through the following research questions:

- Did the participants use *eSeniorCare* (usage tracking and surveys)?
- What is the impact of *eSeniorCare* on participants' HRQOL (SF12v2 instrument [22]) and participants' risk of depression (Geriatric Depression Scale [23])?

II. Related Work

The increasing popularity of smartphones/tablets has led to the development of many applications for medication management and lifestyle management. The medication management applications provide reminders when a medication is

due, medication dosage history and side effects, and refill alerts [17], [24], [25]. Many of these applications have been designed for managing specific chronic conditions like diabetes, and hypertension; and have been proven to be effective in improving medication adherence [26], [27]. However, very few applications have been specifically designed for seniors and/or were designed by involving the seniors in the design process [28]–[31].

Smartphone applications have been used for personalized exercise programs for seniors [32]. The Qi-Gong App used tablet-based exercise training video to promote physical exercise among seniors [33]. The seniors enjoyed the portability and the time flexibility. However, the video could not be stopped in the middle nor it could started for any point. The smartphone applications have also been developed for recording food intake [34], [35].

The characteristics of the tablet itself can have a positive effect on the health of the seniors. The informal look and feel of tablets and touch based-interactions lower barriers to adoption and create positive feelings towards the tablet among older adults with no computer experience [36]. The seniors can perform tasks more efficiently on a tablet compared to that using a keyboard and a mouse [36]–[41]. However, the extra sensitive touch screen, and screen glare can make interactions difficult [38]. These difficulties can be overcome by using a stylus. Some of the other barriers to tablet adoption are the design of technology, perception of need for technology, physical health and cognitive health [42]–[46]. To overcome these barriers, technology training classes have been organized that are specially designed for seniors [47]–[49]. These classes have identified repetitions as key to success for technology adoption. Adequate training has a positive impact not only on older adults' skill in technology use but also on their attitudes towards it [46].

Many research studies have been conducted to study the impact of computer use and internet use on depression and quality of life [50]. There is a considerable variation in the findings of these research studies related to the impact on depression and psychological well-being [51], [52]. A study conducted with 460 participants found a positive correlation between computer use and well-being of the seniors [53]. On the other hand, another study did not find any causal relationship between the above variables [54]. Further, a limited number of studies have been conducted to study the impact of tablets on the quality of life of seniors. A study conducted in UK with 77 seniors in 11 resident care facilities found that the tablet use promoted interpersonal interactions and intergenerational interactions [38]. In a different study, 25 residents, with no prior computer experience, received extensive training in using the iPad and associated applications [55]. Measurements revealed a significant difference in participants' optimism and engagement with computers because of training and tablet use. However, no significant differences were found in life satisfaction, depression and sense of loneliness.

III. Application Design

We scoped the features of *eSeniorCare* based on literature review and user feedback sessions. *eSeniorCare* is an Android-based tablet application developed to help seniors track their daily activities and medication intake. We also developed a web portal to help the Resident Life and Health Administrator (RLHA) track the missed medications, refill alerts and medication changes so that he/she can take the necessary action, thus ensuring continuity of care. RLHA is a staff member in the Aging in Place (AiP) program at a local hospital, who is responsible for catering to social and health needs of AiP participants. While the mobile platform development is in progress to include the comprehensive elements driving successful aging, in this work we focus on the following features and their collective impact on physical functioning and emotional well-being. In this section, we provide a brief overview of the components of *eSeniorCare* [56].

A. Medication Management

The participants receive reminders to take their medications five minutes before the intake time (Figure 1a and Figure 2a). The reminder provides a list of the medications that are due at that particular time, along with their dosages, image of the medication, and audio speaking the name of the medication. The participants have to click a checkbox to confirm the medication intake. They can also view their medication history as well as a list of currently prescribed medications. They can even record the intake of all PRN (pro re nata or medications taken as required) medications. A complete description of this component can be found in [57].

B. Observations of Daily Living

Observations about an individual's daily activities or tracking ones daily activities can be representative of the person's health risks. The information on various daily activities like sleep, and exercise can provide valuable information on one's health to the clinicians. As a part of this application component (Figure 1b and Figure 2b), the users are asked to answer questions every day in the morning and in the evening [56]. The participants set their goals or plans for the day, as a part of the morning questions and enter their activities accomplished for the day, as a part of the evening questions. The participants could choose from a set of options to set their goals for the day. However, from our feedback sessions, we found that the prescribed set of goals did not cover all the activities/goals that the participants intended to perform in a day. Hence, we added a text box where the participants could input the activities outside the set of listed goals in *eSeniorCare*. The users can schedule alarms for answering the morning and evening questions because they might not remember to answer them.

C. Web Portal

All the information entered by the participants through the platform (as described in Subsections III-A and III-B) is accessible to the RLHA via a web portal (Figure 1c). In the

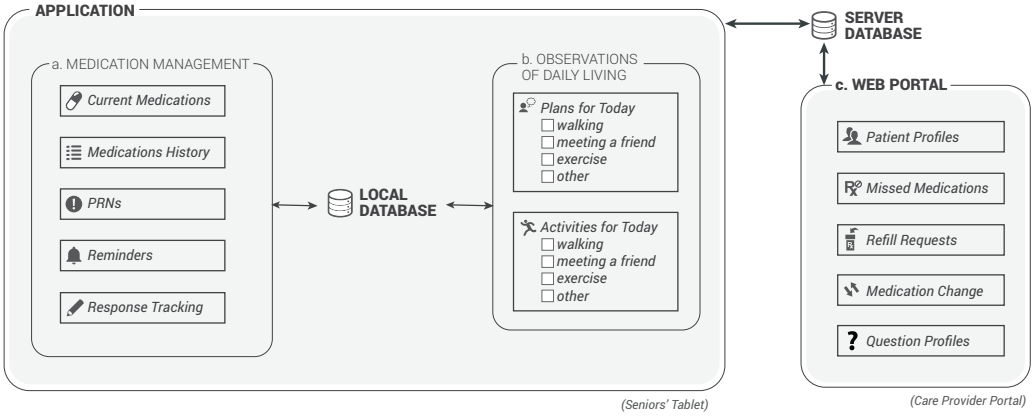


Fig. 1. eSeniorCare: Features

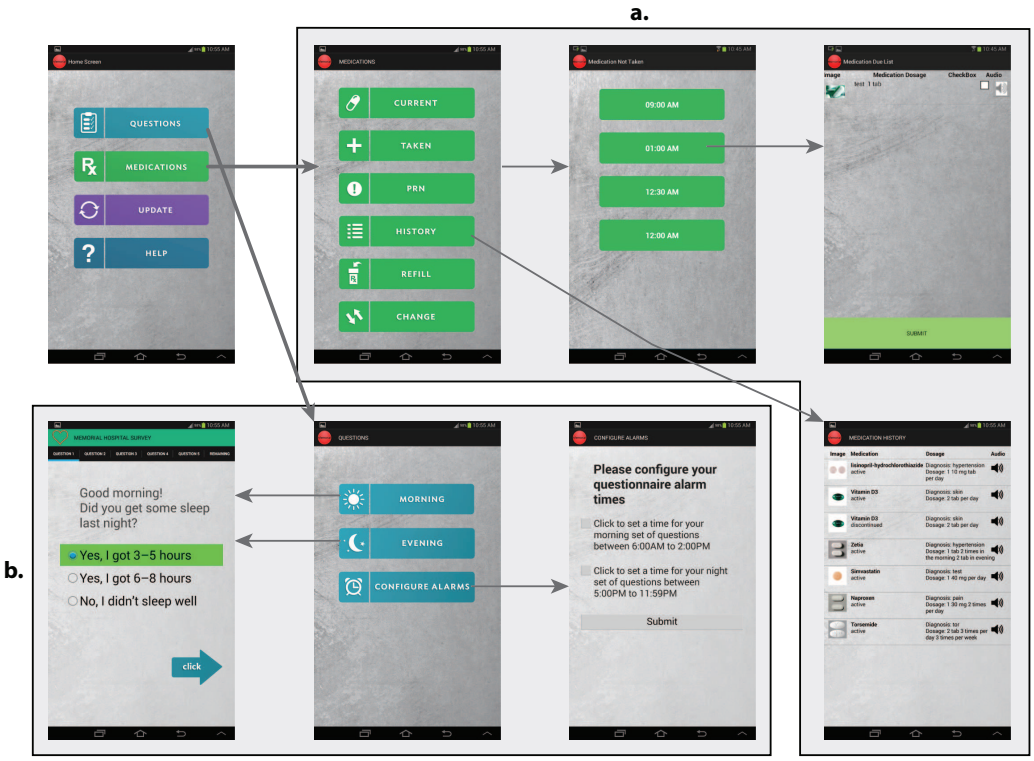


Fig. 2. eSeniorCare: Application Screenshots **a.**: Medication Management **b.**:"Observations of Daily Living"

event of missed medication (indicated by the check box in the medication reminder not clicked), the RLHA is notified through the portal so that he/she can take the necessary action, thereby ensuring continuity of care. The RLHA also used this portal for creating the user profiles, and maintaining (entering and updating) their medication and question (morning and evening) profiles.

IV. Methods

We conducted this study in collaboration with the AiP program developed by Community Health Enhancement (CHE) initiative at Memorial Hospital of South Bend. The AiP program is geared towards assisting low-income seniors, residing in independent living facilities, and maintain their independence. We collaborated with the program to maintain the HRQOL of the participating seniors through the use of a tablet-based application (*eSeniorCare*).

We obtained IRB approval to conduct this study from both University of Notre Dame and Memorial Hospital of South Bend. Following the approval, we conducted an interest meeting at a local independent living facility and introduced the purpose of our study to the residents. Many residents volunteered to participate in the study and signed a consent form. We only recruited those who were:

- Cognitively intact, based on their performance on St. Louis University Mental Status Exam (SLUMS), a 30-

point screening questionnaire that tests for orientation, memory, attention, and executive functions [58].
- Fluent in English and had good vision.
- Diagnosed with at least one chronic condition.
- Prescribed at least one medication.

We collected the demographic information for the participants, and provided a password-protected and encrypted 7-inch Samsung Galaxy Tab 2.0 tablet to each participant. They were expected to carry the tablet at all times and report their daily activities and respond to medication intake reminders generated by the *eSeniorCare* application.

A. Participants

We recruited 16 participants—5 male and 11 female. The demographic information of the participants is given in Table I. They had an average age of 66.8 years (SD $= 9.2$) and a median age of 62.5 years. The majority of the participants ($n = 12$) were African American/Black and were unemployed. For this reason, we did not consider race/ethnicity and employment status for answering our research questions.

B. Study Design

We conducted a 31-week-long pilot study to evaluate the usability of *eSeniorCare* and its impact on participants' HRQOL and risk for depression. The study was conducted in two phases [56]. During the first phase (the first eighteen weeks), the participants used only the "Observations of Daily Living" component (Subsection III-B). During the second phase (the final twelve weeks), participants used both components (Subsection III-A and III-B), tracking their daily activities and managing their medication intake with the application.

C. Training

We organized six workshops (Table II) over nine weeks for training the participants. The workshops were on average about one-and-a-half hours long and introduced the basic functionality of the tablet, such as use of Home and Back buttons and understanding how to adjust the screen backlight. During each session, we provided a focused overview of a particular skill or application (e.g. web browsing, taking pictures, social media, etc.), providing step-by-step instructions on its use and making it relevant to the participants. We also used the sessions to answer participants' questions or concerns and to provide one-on-one help. Two additional workshops were conducted to train participants to use the *eSeniorCare* application.

The RLHAs played an important role in leading the workshops, and addressing participants' concerns. The RLHAs also made themselves accessible at all times outside the workshops to address queries or concerns about using the tablet and the application. Our goal was to continue to provide support until participants became confident in their ability to use the tablet and *eSeniorCare*.

D. Evaluation Metrics

We used following measures to study the usability and impact of the *eSeniorCare* on the participants' HRQOL:

1) Usability of eSeniorCare: To answer our first research question (usability of *eSeniorCare*), we used the following the following metrics:

- System Usability Scale (SUS): It was used to determine the usability of *eSeniorCare* [59]. It is a 10-item questionnaire with every item having 5 options 1 to 5 in increments of 1; with 1 being Strongly Disagree and 5 being Strongly Agree. SUS was administered twice during the study. The first one was conducted four weeks after the release of the medication management component (start of the second phase) and the second one was conducted 6 weeks after the first SUS (2 weeks before the end of the study). The purpose of second SUS was to evaluate perceived difficulty in using *eSeniorCare* after the discontinuation of workshops. We followed the standard scoring procedure to calculate the usability score.
- Final Feedback Questionnaire (FFQ): A custom 38-item questionnaire was used to gather participants' perceptions on the effectiveness of the study and the usability of the application. Sample questions are listed in Table IV. The questionnaire was administered both on paper and online, at the end of the entire study.
- Technology Survey Questionnaire (TSQ): It is a custom 13-item questionnaire used to assess the technological skill of the participants. We administered it on paper both at the beginning and end of the study. The sample questions are listed in Table V.
- Usage Logs (UL): Participant responses to medication reminders, morning and evening questions are stored in a database.

2) HRQOL and Risk for Depression: To answer our second research question (the impact of *eSeniorCare* on HRQOL and the risk for depression), we used the following questionnaires:

- SF12v2: It is 12-item health survey provided by Quality Metric to measure the general health and HRQOL of an individual [60]. This unique health survey focuses on the patient's point of view of his/her own physical and mental health, and compares their scores to the US general population norm. We administered it on paper both at the beginning and end of the study.
- Geriatric Depression Scale (GDS): It is a 15-question screening tool used for measuring risk of depression in seniors [23]. We administered paper-based GDS both at the beginning and the end of the study. According to the standard scoring procedure, a score greater than 5 on GDS is suggestive of depression and may require a follow-up interview. Scores greater than 10, almost always, imply depression.
- We also used FFQ to evaluate the effectiveness of the study.

E. Usage Scoring System

We used the responses to the daily questions and medication intake reminders (UL) to define a rating system to track overall

TABLE I
DEMOGRAPHIC DISTRIBUTION

Variable	Options	Total	Male	Female
Gender	Male	5(31.25)		
	Female	11(68.75)		
Education (in years)	9-11	2(12.50)	-	2(12.50)
	12	4(25.00)	2(12.50)	2(12.50)
	13-15	8(50.00)	2(12.50)	6(37.50)
	16	1(6.25)	1(6.25)	-
	16+	1(6.25)	-	1(6.25)
Age(in years)	55-64	9(56.25)	5(31.25)	4(25.00)
	65-74	3(18.75)	-	3(18.75)
	75+	4(25.00)	-	4(25.00)
Race/Ethnicity	African American/Black	12(75.00)	4(25.00)	8(50.00)
	Non-Hispanic White	3(18.75)	1(6.25)	2(12.50)
	Unidentified	1(6.25)	-	1(6.25)
Employment Status	Employed	4(25.00)	2(12.50)	2(12.50)
	Unemployed	12(75.00)	3(18.75)	9(56.25)

Note: The values for Total, Male and Female columns are formatted as the number of participants in that variable-options (the percentage as a whole).

TABLE II
TOPICS COVERED IN THE WORKSHOPS.

Workshop #	Topics Covered
1	Using the camera and video recorder
2	Creating email addresses and sending emails
3	Installing applications from Google Play
4	Using Pandora, YouTube and Pinterest
5	Review of previous workshops
6	Using Skype to connect with Friends and Family
7,8	Using *eSeniorCare*

application usage for each participant. A rating of 1 was given if the participant acknowledged any reminder related to *eSeniorCare* application (medication or question reminder). Thus, the maximum possible daily rating for the participant is then equal to the sum of number of times per day that a medication is due to be taken, the morning and evening questions. Based on this daily rating system, we calculated the weekly rating (WR) as the sum of the ratings for all the days of a week divided by the sum of the participant's maximum possible daily rating for the week (thus taking into account the variation in the number of daily reminders among the participants arising from the number of medications and different dosage time frequency). A sample weekly scoring for a participant is described in Table III. We averaged the WR over the course of the study to obtain the average weekly rating (AWR) for a participant.

V. RESULTS

In this section, we provide the results from the study of *eSeniorCare* for evaluating its usability, and the impact on HRQOL and risk for depression of the participants.

A. Did the participants use eSeniorCare?

To answer this research question, we evaluated the usability of *eSeniorCare* along the following dimensions:

- Usability of *eSeniorCare*: Examining the overall usability of *eSeniorCare*.
- Technology Skills Assessment: Evaluating the effect of *eSeniorCare* on perceived technological skill of the participants.
- *eSeniorCare* Usage and Technology Skill Rating: Determining the factors influencing the change in technological skill at the study.

1) Usability of eSeniorCare: We evaluated the usability of *eSeniorCare* using SUS and FFQ. 10 out of 16 participants in our study found *eSeniorCare* easy to use (Table IV Q1). About 56.25% of the participants felt that they were able to quickly complete the tasks using the different features ("Observations of Daily Living" and "Medication Management") [Table IV Q2], while the majority ($n = 12$) of the study participants found *eSeniorCare* easy to learn (Table IV Q3). About 11 participants found *eSeniorCare* fun to use (Table IV Q4). About 62.5% of these participants felt that *eSeniorCare* worked exactly the same way as they intended it to work (Table IV Q5). The UL scores varied from 0.11 to 0.88 with a median of 0.57.

More than 65% of the participants liked the look and feel of the application (Table IV Q6-Q8). The font size and the size of the checkbox or the radio button are very important because the seniors have multiple comorbidities that limit their mobility, vision and motoring capabilities. 62.5% of the participants would continue using *eSeniorCare* (Table IV Q12) while 93.75% would use the tablet (Table IV Q13). Overall, 87.5% of the participants would recommend *eSeniorCare* to a friend (Table IV Q14). The high percentage of participants willing to continue using *eSeniorCare* and the tablet implies good usability of *eSeniorCare*. Initially, the participants faced difficulty in learning the new technology. However, as they became familiar with the technology, they became more confident and began to appreciate the benefits of *eSeniorCare*. The participants, who were initially on the verge of quitting from the study, wanted the study to never end.

Some of the comments from the participants provided at the end of the study are stated as follows:

TABLE III
USAGE SCORING SYSTEM: SAMPLE

Type	Med†Responded	Med†Total	Quest‡Responded	Quest‡Total	Total*	Maximum Total	Score
Day 1	2	2	2	2			
Day 2	3	3	1	2			
Day 3		2	1	2			
Day 4	2	4	2	2			
Day 5	2	2	2	2			
Day 6	2	2	2	2			
Day 7	2	2	2	2			
Total	13	17	12	14			
Grand Total					(13+12 = 25)	(17+14 = 31)	
Overall Score							25/31

†Med: Medication Reminder. ‡Quest: Question Reminder (Morning and Evening). *Total number of responses entered by a participant in the week.

"Excellent program. I hope it continues for other people in the community."

"I enjoyed this program in most part. When it first began, I did not like and I stuck with it."

"all my friends want one. really nice and enjoyed using it."

"very good application and program."

We have SUS scores available for 13 participants only. We observed a wide variation in score among participants for both dates. The scores ranged from 32.5 to 72.5 on the first date while they ranged from 30 to 77.5 on the second date. However, there was no statistically significant difference between the SUS scores.

2) Technology Skills Assessment: The majority of the participants ($n = 9$) had rated their technology usage skills to be naïve or beginner at the beginning of the study (Table V Q3: Pre Trend). About 12.5% of the participants were unsure to the point of quitting from the study. The majority of the participants ($n = 13$) reported a technological skill greater than or equal to moderate technological skill rating at the the end of the study (Table V Q3: Post Trend). We numerically coded the responses for this question related to the level of technological skill (Table V Q3). We gave a rating from 1 to 5, with 1 corresponding to naïve (No skill) to 5 being Excellent. Based on the paired t-test between this rating at the beginning of the study and that at the end of the study, we found a statistically significant difference in the way participants rated their technical skills (t-statistic: 2.23 and p-value: 0.04) at the beginning of the study compared to that at the end of the study. This change can be attributed to the increased familiarity with the tablet and *eSeniorCare*.

We found that there was an increase in the number of participants using the Internet to find friends (from $n = 4$ to $n = 6$) [Table V Q2: Look], read newspaper (from $n = 3$ to $n = 5$)[Table V Q2: Read], download music/movies (from $n = 3$ to $n = 8$) [Table V Q2: Download], and look up phone numbers (from $n = 7$ to $n = 8$) [Table V Q2: Look up] at the end of the study, in comparison with that at the beginning of the study (Table V Q2).

3) eSeniorCare Usage and Technology Skill Rating: The majority of the male ($n = 4$) and female ($n = 9$) participants reported moderate to excellent technological skill at the end of the study (Table VI Gender). Further, most of the participants having either 9-11 years of education ($n = 2$), 13-15 years ($n = 4$) or 16 years of education ($n = 1$) rated their technological skill higher at the conclusion of the study than that at the start of the study (Table VI Education (in years)). However, we noticed a decrease in reported technological skill rating for a small proportion of the participants in the remaining education groups. Further, the majority of the participants in all the age groups 55-64 years (50%), 65-74 years (100%) and 75+ years (50%) rated their post-study technology skill higher than their pre-study skill (Table VI Age (in years)). For the old-old age group (75 years or more), 1 participant gave a lower rating at the end of the study than that at the launch of the study. Looking at the usage of the participants (Table VI Usage), we did not observe any trend with the technological rating at the end of the study.

B. RQ2: Did eSeniorCare impact the health-related quality of life and risk for depression?

To answer this research question, we used the information from two questionnaires: SF12v2 and GDS, collected at the beginning and at the end of the study. Some of the participants ($n = 7$) reported showing the *eSeniorCare* application to their physician (Table IV Q15).

1) SF12v2: Nine participants completed the SF12v2 questionnaire. We estimated the scores for the remaining participants using the missing data estimation supplied by the SF12v2 scoring software [61]. We ignored the data for 1 participant because he/she joined the study at the beginning of the second phase. 56.25% of the participants had a post-study physical composite score (PCS) score greater than or equal to that at the beginning of the study. The pre-study PCS ranges from 26.25 to 57.34 with a median of 42.21 (Figure 3(a): Pre Study), while the post-study score varies from 31.37 to 56.03 with a median of 46.95 (Figure 3(a): Post Study). On the other hand, the pre-study mental composite score (MCS) scores had values ranging from 34.56 to 71.26 (Figure 3(b): Pre Study) whereas the post-study MCS scores ranged from 38.17

TABLE IV
QUESTIONS AND RESPONSE TRENDS FOR THE FINAL FEEDBACK QUESTIONNAIRE.

Num.	Question Text	Feedback Trend
Q1	The *eSeniorCare* application was easy to use.	2 8 3 1 2
Q2	I was able to complete the "modules" quickly in *eSeniorCare*.	1 10 2 1 2
Q3	It was easy to learn to use *eSeniorCare*.	12 2 1 1
Q4	*eSeniorCare* is fun to use.	1 10 3 1 1
Q5	*eSeniorCare* works the way I want it to work.	10 2 3 1
Q6	The layout of the screen made sense; the icon for each button was self-explanatory.	2 11 2 1
Q7	The "look" of this system was pleasant (fonts, colors, etc.).	1 12 2 1
Q8	When using *eSeniorCare* I could easily see the buttons on the screen.	2 11 1 2
Q9	The system gave error messages that clearly told me how to fix problems.	1 5 6 3 1
Q10	I use *eSeniorCare*/tablet at home.	2 12 2
Q11	I take the tablet with me, whenever I go outside.	5 4 5 2
Q12	I would continue using *eSeniorCare*.	1 9 5 1
Q13	I would continue using the tablet.	6 9 1
Q14	I would recommend *eSeniorCare* to a friend.	3 11 1 1
Q15	I showed *eSeniorCare* to my physician.	7 2 5 2

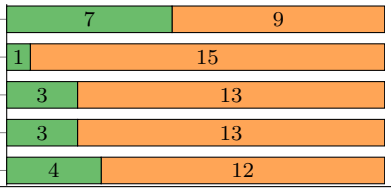
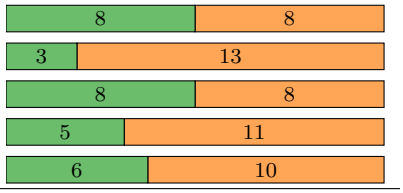
Note: The bar segments from left to right correspond to the responses "Strongly Agree" (green), "Agree" (orange), "Neither Disagree Nor Agree" (blue), "Disagree" (purple), and "Strongly Disagree" (brown). For each segment, the value denotes the number of participants with the response, while its length denotes the proportion.

to 62.13 (Figure 3(b): Post Study). We observed a decrease in MCS scores for 9 participants. The smaller sample size preempts us from making statistically significant conclusions. But we include these scores in this paper as an experimental framework to measure impact and evaluate it longitudinally.

To study the variation of PCS and MCS with age, we divided the participants into three age groups: between 55-64 years, 65-74 years and greater than or equal 75 years. We chose this binning of age to be consistent with that used for the age-controlled US norms for PCS and MCS, provided by the SF12v2 scoring software [61]. We observed an interesting trend between the post-study and pre-study mean PCS scores among the different age groups (Figure 4(a)). There was a slight increase in the mean PCS score among the participants in the lowest age group at the end of the study compared to that at the beginning of the study and both the post and pre study scores were above the US Norm value [61] for this age group. We found that there was a considerable increase in this score for oldest age group at the termination of the study. However, there was no change in the score for middle age group. The PCS scores for the middle and oldest age groups were below their respective US Norms, both at the start and at the end of the study. Though there was a decrease in the mean MCS scores at the conclusion of the study when compared to that at the beginning of the study for 55-65 years age group, the scores were still above the US Norms for this age group (Figure 4(b)). However, the post-study mean scores decreased and went below the US average for the other two age groups.

2) Geriatic Depression Scale: A score between 5 and 10 on GDS implies risk for depression. One participant was at the risk of depression at the beginning of the study (Table VII). However, upon analysis of the GDS scores at the end of the study, we found that there are no participants with a score greater than four (Table VII). This implies that participant's risk of depression was lowered as a result of participation in the study. In addition, the GDS scores remained unchanged for majority ($n = 10$) of the participants and decreased for 3 participants. There was a slight increase in the GDS scores (but still not at risk) for 2 participants.

TABLE V
QUESTIONS AND RESPONSE TRENDS FOR THE TECHNOLOGICAL SURVEY QUESTIONNAIRE.

Num.	Question Text [Options]	Pre Trend	Post Trend
Q1	How often (per day) did you use the Internet? [0–3 times, 4–6 times, 10+ times]		
Q2	What types of things did you do on the Internet? [Yes, No]		
Q3	How would you rate your tech/-savvy skills? [Naïve, Beginner, Moderate, Good, Excellent]		

Note: The bar segments from left to right correspond to the response options listed in brackets with the question text. For each segment, the value denotes the number of participants with the response, while its length denotes the proportion.

TABLE VI
DISTRIBUTION: FACTORS AFFECTING TECHNOLOGICAL SKILL RATING

Type	Options	TSR†									
		Naïve		Beginner		Moderate		Good		Excellent	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Gender	Male	0	0	1	1	1	2	2	0	1	2
	Female	0	1	8	1	2	7	1	0	0	2
Education (in years)	9-11	0	0	2	0	0	2	0	0	0	0
	12	0	1	3	0	0	3	1	0	0	0
	13-15	0	0	3	1	3	4	1	0	1	3
	16	0	0	0	0	0	0	1	0	0	1
	16+	0	0	1	1	0	0	0	0	0	0
Age (in years)	55-64	0	0	2	1	3	4	3	0	1	4
	65-74	0	0	3	0	0	3	0	0	0	0
	75+	0	1	4	1	0	2	0	0	0	0
Usage		-	0.48	-	0.34-0.61	-	0.11-0.73	-	-	-	0.41-0.88

†Technological Skill Rating.

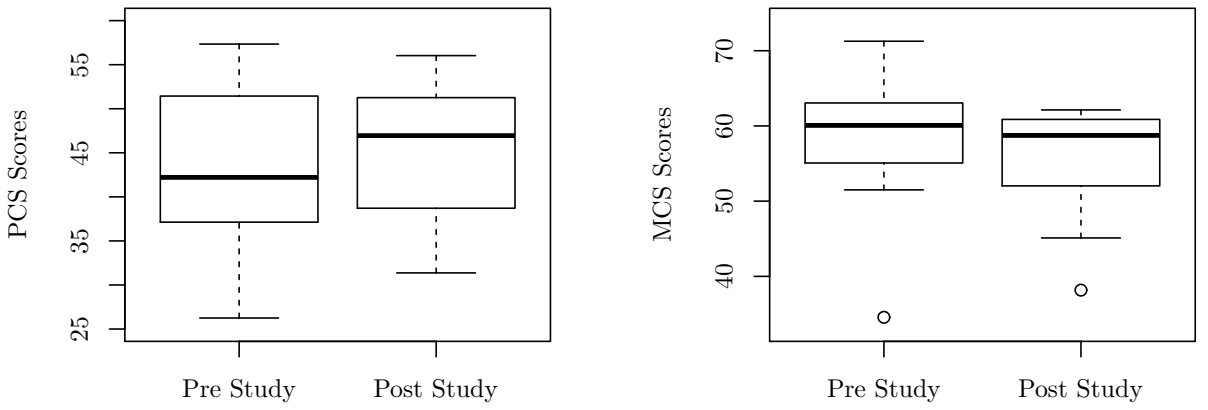
TABLE VII
TABLE SUMMARIZING THE SCORES FOR GERIATRIC DEPRESSION SCALE (GDS)

ID	Pre	Post
1	0	1
2	0	0
3	1	1
4	0	0
5	4	4
6	3	1
7	**6***	**2**
8	3	3
9	0	0
10	1	0
11	3	3
12	0	0
13	1	2
14	3	0
15	0	0
16	-	2

*GDS Score greater or equal to 5.

VI. DISCUSSION

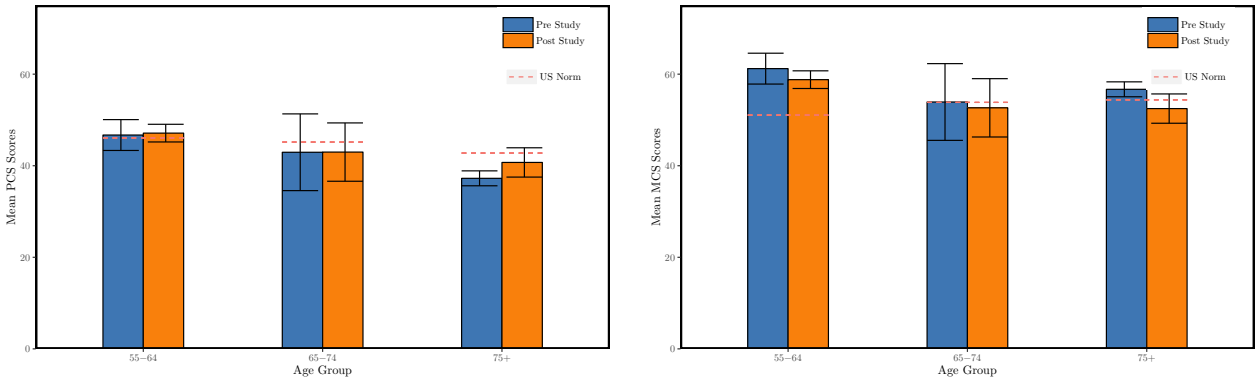
The main objective of our study was to evaluate the usability of *eSeniorCare*, and its impact on physical functioning and mental well-being (HRQOL), and risk for depression. As a part of 31-week long study, the participants (people aged 55 years and older) used a tablet-based application to fill out their plans for the day as part of morning questions, and the activities performed for the day as part of the evening questions. They also recorded their medication intake using this application. The RLHA used a web portal to track the participants' medication intake. All the participants completed the study. The majority ($n = 13$) of the participants liked the look and feel of the *eSeniorCare* application and found it easy to use ($n = 10$). Further, the participants ($n = 11$) felt that they could complete the tasks in *eSeniorCare* quickly. The majority of the participants would continue using the *eSeniorCare* application ($n = 10$) and would recommend it to a friend ($n = 14$). Further, we observed an improvement in technological skill for the majority of the participants ($n = 9$). However, these participants had a varying education



(a) *eSeniorCare*: Physical Composite Score (PCS)

(b) *eSeniorCare*: Mental Composite Score (MCS)

Fig. 3. *eSeniorCare*: Variation in SF12v2 Scores: Beginning and End of the study



(a) *eSeniorCare*: Physical Composite Score

(b) *eSeniorCare*: Mental Composite Score

Fig. 4. *eSeniorCare*: Variation in SF12v2 Scores and Age Groups: Beginning and End of the study. Note: The US Norms values for the scores corresponding to each age group are obtained from SF12v2 scoring software.

background (some not having a college degree) and varying age (1 participant being more 75 years). Research has shown that seniors with varying education background and age can have high technological proficiency with proper training and repitition [47]–[49], even though college educated seniors and lower age demonstrate high computer interest or technology use and low computer anxiety [62], [63].

The majority of participants ($n = 9$) also reported a higher SF12v2 physical health score at the end of the study compared to that at the beginning of the study. However, the majority ($n = 9$) of the participants had a decrease in their MCS scores at the conclusion of the study compared to that at the beginning of the study. The lower MCS scores can be attributed to the multiple chronic conditions that the participants are diagnosed with. The majority of the participants ($n = 13$) reported to have at least three chronic conditions. This is in accordance with studies which have shown that people with at least 2 chronic conditions have a lower MCS scores compared to those with less 2 chronic conditions [64], [65].

Studies have shown that technology, when used properly, has the potential to lower depression levels [54]. For example, when used to connect with friends and family, technology can reduce loneliness and hence, lower depression levels [66]. On the other hand, technology, when used to find explanations or solutions for health issues, can increase depression and detach individuals from the outside world [67]. The participants used *eSeniorCare* application for 31 weeks. This might explain the reason for decrease or change in post-study GDS scores for majority of the participants ($n = 12$). External factors such as social interaction with local community or other

residents living in the same independent living facilities; and the participant's own ability to make lifestyle changes might have been equally or partially responsible for this change. In particular, RLHAs observed that community-room social interactions among participants significantly increased during the study. Participants were seen conversing with each other holding tablets in their hands.

A. Design Recommendations

Based on the results/observations of our study, we recommend the following the design choices for the development of tablet-based applications catered to low-income older adults residing in independent living facilities:

- The application should support offline functioning (without internet connectivity) because the low-income independent living facilities, in most cases, do not provide Wi-Fi connectivity.
- A visual representation of the activities tracked and follow-up by the care provider would improve engagement with the daily activity tracking.
- Training workshops should be organised regularly for increasing familiarity with the application (technology). We noticed a drop in SUS scores after the discontinuation of workshops. Further, repetition is a key to success.

B. Limitations

We are expanding the focus and participant group for the next iteration. This study, however, provided us with important feedback and learning elements on our iterative design and development components. We are also incorporating a control group to perform a comparative analysis and draw conclusions about the impact of *eSeniorCare* on participants' HRQOL. Finally, we conducted the study during winter when the town experienced one of the worst winters of the decade. Since season has a considerable impact on the quality of life, depression and happiness levels of individuals, a year long study might be useful to offset the impact of seasonal variations [68].

VII. Conclusion

In this work, we focused on the evaluation of *eSeniorCare*, a technology-based platform aimed at maintaining their physical functioning and emotional well-being (health-related quality of life) of seniors residing in independent living facilities. Based on the analysis of our data gathered through the usage of this platform and our assessments, we found that *eSeniorCare* improved the technological skill of the participants. Though the participants were initially overwhelmed with *eSeniorCare* we found that they enjoyed using this platform and their familiarity with the platform increased through training workshops and one-on-one interactions with the RLHA. We also observed that the participants had reduced risk of depression through usage of *eSeniorCare*. Further, *eSeniorCare* allows seniors to take charge of their physical and mental health and integrates them with their care providers (RLHAs).

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