Developing ASSISTwell, a tablet application to support older adult's self-management of symptoms of chronic conditions

Cynthia Jacelon PhD RN-BC CRRN FGSA FAAN[a,*]

Raeann LeBlanc PhD DNP AGCNP[a]

Mohammad Alkhawaldeh PhD RN[b]

John Ridgway PhD[c]

Jenna Marquard PhD[d]

Jeung Choi PhD MPH RN[a]

[a]College of Nursing, University of Massachusetts, 126 Skinner Hall, 651 N. Pleasant St., Amherst, MA, USA; [b]College of Nursing, Johns Hopkins University, Baltimore, MD, USA; [c]Jacelridge Associates, Greenfield, MA, USA; [d]College of Engineering, University of Massachusetts, Amherst, MA, USA; *Corresponding author: jacelon@nursing.umass.edu

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Objectives To develop ASSISTwell, a theoretically based tablet application designed specifically for older individuals' self-management of symptoms of multiple chronic conditions. **Methods** The development process used a participatory approach including five steps: gerontologic nurses developing use cases, development of a prototype, demonstrating the prototype to focus groups of older individuals and registered nurses to obtain feedback and recommendations, and programing a beta version of ASSISTwell. **Results** Focus group participants commented on the utility of the program, likely users, the user interface, and design features. Their comments informed the development of the beta version of ASSISTwell. ASSISTwell includes provisions for self-management of health, attitude, autonomy, activity, and relationships. The application is simple, clear, and has easy-to-read fonts and colors. It runs on Android devices and uses a functional approach to assist older individuals in self-management. **Discussion** Technological aids for self-management of symptoms of multiple chronic conditions are proliferating. However, most of these are for single diagnoses, are heavily focused on surveillance by healthcare providers, and not specifically designed for use by older individuals. Using a participatory approach to obtain early feedback from end users can improve the utility of computer applications.

Keywords: older adults, self-management, multiple chronic conditions, technology

The number of older adults in our society is growing rapidly. As many as 85% of these individuals have one chronic health condition[1] and at least 75% have two or more chronic conditions[2-4]. The activities required for self-management of chronic conditions are similar across conditions, and include taking medications, monitoring physiological signs (e.g., blood pressure, blood sugar), and making decisions about care[5]. Living with multiple chronic conditions can be complicated for older individuals and requires self-management to balance health demands with other aspects of daily living.

New technologies hold promises for supporting self-management of multiple chronic conditions, however older individuals may not benefit from off-the-shelf technologies designed for the general population. Off the shelf technologies may have user interface features, such as small fonts, lack of contrast on screens, and extraneous features, that make them difficult for older individuals to use. We used human factors approaches, including older adult end users and healthcare providers early in the design process, to develop a tablet-based computer program (ASSISTwell) to help community-dwelling older adults self-manage their chronic health conditions with the goal of achieving optimal wellness.

Background

Self-management of symptoms of chronic conditions

"Self-management is a dynamic process in which individuals actively manage [symptoms of] chronic illness"[6]. It is more than compliance or adherence to health prescriptions; it is a personalized strategy for living with the symptoms of chronic conditions while minimizing disability and promoting optimal wellness. Self-management implies that the individual with multiple chronic conditions engages in daily management of their symptoms by making informed decisions regarding health and life choices.

Ineffective self-management may lead to exacerbations of symptoms and accounts for up to 30% of hospitalizations of older adults each year[7]. Individuals with multiple chronic conditions use more hospital days, office visits, home health care, prescription drugs, and other healthcare services. In the United States, an estimated 66% of all Medicare spending is used to treat individuals with five or more chronic conditions[8]. In response to these costs, many disease management programs have been developed for single conditions such as diabetes[9], asthma[10], and heart failure[11,12]. However, few programs use a functional approach to support management of multiple chronic conditions.

Computer-assisted self-management

There are many programs of research focused on improving self-management, however most are focused very narrowly on specific disease processes, or are designed for healthcare provider surveillance. Of the thirty studies included in a recent review of technology for self-management[13], twenty-two systems were designed for individuals with a single chronic disease; eight of these were for individuals with congestive heart failure[14,21], six for individuals with chronic obstructive pulmonary disease[22,27], and eight for individuals with diabetes[28,35]. Only five self-management systems were designed to be used by individuals with more than one chronic condition[36,41]. Common strategies employed included transmission of health data such as vital signs, blood pressure, oxygen saturation, blood sugar and weight to healthcare providers[42,43]. A key feature of all of these studies is that the technology was primarily designed for surveillance by healthcare providers, as opposed to using a functional approach to self-management by the older adults themselves. New mobile devices developed with older adults' input on perceived usefulness[44] could enhance function and improve older adults' abilities to manage the symptoms of their chronic conditions. These technologies use physiological, psychological, and sociological data to maximize older adults' abilities to manage the symptoms of their chronic conditions, activities, independent living, function, safety, and quality of life at home. This is accomplished by the device storing symptom and health management information, providing accurate and timely information to older adults to enhance their self-management, and if the older individual so chooses, sharing reliable information to their healthcare providers.

Systems designed to provide older individuals with information about their symptoms in order that they may focus their self-management on improving overall function regardless of the underlying pathology are rare. In the system described here (ASSISTwell), the individual user may choose to share their symptom information with their healthcare provider, but the information will be tailored to the needs of the older individual with the chronic condition.

Older adult's attitudes are generally positive with respect to computer use. Personal computer use has become a meaningful daily activity for many. In addition to providing health information, older individual's computer use could enhance feelings of control, keep their brain active, and provide a vehicle for relating to other people[45]. Older adults were willing to use technology if it helped them stay in their own homes rather than in a more restrictive setting[5,46].

Theoretical Framework

Our goal was to design and test a mini-tablet computer-based self-management application using a theoretically based, functional approach. The underlying framework to our approach to self-management is based upon the World Health Organization's International Classification of Functioning, Disability, and Health (ICF)[47]. The ICF describes function as "…a dynamic interaction between health conditions and contextual factors, both personal and environmental" (p. 4). Based on this approach, the focus of interventions is not on the underlying pathology but rather on the symptoms of chronic disease and the effect of those symptoms on daily function.

Using qualitative descriptive methods, Jacelon developed the Maintaining Balance Model for self-management of the symptoms of chronic conditions[5]. In this model, the concept of self-management is broadly focused, incorporating many aspects of an older individual's life beyond merely managing disease processes. Individuals balance the management of their health, attitude, autonomy, activity, and relationships in their daily lives. Symptoms of chronic conditions affect all aspects of an individual's life, and the Maintaining Balance Model demonstrates that across the continuum of diseases individuals

must engage in similar types of functional activities to manage the symptoms of their chronic conditions while promoting optimal wellness in their daily lives. Viewing self-management from this perspective provides a way to identify cost-effective strategies for self-management of symptoms and promotion of personal health across disease processes and to explore the challenges of self-management from a functional perspective. This functional approach is unique in that few scientists have considered chronic diseases from this perspective. In general technologies for management of chronic conditions have been geared toward healthcare provider surveillance, not older adult self-management; and have been focused on particular diseases, not the functions required to manage disease symptoms.

Methods

The specific aim of this pilot project was to develop and test a mini-tablet based computer tool to support older adult's self-management of chronic health problems.

The steps in the development process were to:
(i) Create the scenarios or use cases for ASSISTwell.
(ii) Create an ASSISTwell prototype.
(iii) Using focus groups, test the tablet-based prototype user interface with older adults.
(iv) Using focus groups, test the tablet-based prototype provider interface with healthcare providers.
(v) Revise ASSISTwell based on user feedback.

ASSISTwell was developed by an interdisciplinary team comprised of two gerontological nurses, an engineer with expertise in human factors, a computer scientist, and two nurse informaticists using an iterative process comprised of the five overlapping tasks listed above. The first task was to develop clinical plans to describe the proposed scope of activities to be included in ASSISTwell.

During step two, the ASSISTwell prototype was created by undergraduate college students in a Software Engineering course from the use-cases, and based on the clinical plans developed in step one. The user interface is the part of the computer tool that the user sees on the screen. To be effective, a device must be usable: the end users must be able to accomplish their goals quickly, easily and with minimal frustration. The device interaction should be simple and intuitive and minimize the cognitive processing required. The design and development of an effective user interface necessitate early and ongoing participation of the end users. This process is known as user-centered design. In user-centered design, the end users (the older individuals and care providers) play a central role in the initial design of the user interface, the underlying human-machine interaction, and in the development process[48,49].

The next task was to refine the user interface to be appropriate for older individuals and care providers. We used an iterative approach employing serial focus groups comprised of older adults (Step 3) and care providers (discharge planning and home care nurses) (Step 4) to develop the beta version of ASSISTwell (Step 5). The focus groups were conducted according to the guidelines developed by Krueger and Casey's[50]. The focus group recordings were transcribed and analyzed using NVivo to aid the process.

Protection of human subjects

Prior to holding focus groups of older individuals and nurses, approval was obtained from the Committee on the Protection of Human Subjects at the principal researcher's university. Each participant was asked to sign a consent letter that explained the purpose of the research and how their anonymity was maintained. Anonymity was protected by minimizing the use of names during the focus groups, and limiting name use to first names of focus group participants. All data was transcribed by a transcription service familiar with research processes located on the university campus, and encrypted on the PI's computer or locked in a file cabinet in the PI's office and the rules for protection of human subjects were followed. Nurses and older participants were given a $10 gift card as a thank you gift for participation.

Participants

Older adults were recruited using flyers at senior gathering places including a community senior center and an independent living facility. To participate, individuals had to be at least 65 years old, living independently, and have one or more chronic conditions. Each participant was required to read and understand English, and be able to sign informed consent. No previous computer experience was necessary. The purpose of the older adult focus groups was to obtain feedback from potential users, so individuals with global cognitive deficits, such as Alzheimer's disease, were not included. Registered Nurses from several area home care agencies and hospital discharge planners were recruited using a flyer and word of mouth through the College of Nursing network of clinical agencies. In order to participate, the nurses had to have a practice that included community-dwelling older adults living independently.

Results

ASSISTwell was developed using both sequential and iterative processes. In step one, the gerontologic nurses on the team used their expertise to draft use cases based on the Maintaining Balance Model (*Table 1*). For each of the five areas of the Maintaining Balance Model, the nurses determined which measures and activities should be available in ASSISTwell, and at what frequency.

Table 1. Aspects of the Balance Model and Related Use Cases

Theoretical Model	Measurement	Frequency
Activity (maintaining a balance between energy expenditure and energy conservation)		
A) Performing ADLs	A) ADL	A) Weekly
B) Managing IADLs	B) IADL	B) Weekly
C) Fostering mobility	C) Steps walked	C) Daily bedtime
D) Engaging in activities	D) Role Performance	D) Twice a day, noon and bed time
Health (crafting a health management plan)		
A) Monitoring health	A) Health Parameters	A) User activates VS, BP, O2 (twice daily) Blood sugar 4x daily Meals three times a day. User indicates meal composition and amount. Glasses of fluid 1-8 daily
B) Keeping track of medications	B) Medications	B) *ASSIST*well reminds user according to medication schedule. User indicates task complete
C) Learning to live with it	C.1) Sleep scale C.2) Pain Scale C.3) Fatigue scale	C) Daily, PRN
Attitude		
A) Maintaining a positive attitude	A) Positive Attitude	A) Daily, weekly, monthly
B) Finding and creating meaning in one's life	B) Meaning Scale	B) Weekly
C) Accepting losses	C) Mood	C) Daily, PRN
D) Planning for the future	D) Looking forward	D) Daily at bed time
Autonomy		
A) Sustaining independence	A) Rating of Self-management	A) Daily
B) Exercising control	B) Sense of Control Scale	B) Weekly
Relationships		
A) engaging in social situations	A) Social Network Scale – Revised	A) Weekly
B) negotiating family roles	B) Measure of family interaction	B) Weekly

This step defined the scope of actions to be performed by ASSISTwell, and provided an outline for the development of the prototype program.

Step two involved the development a prototype of the program and user interface. After much discussion, the research team chose the mini-tablet computer as the platform for ASSISTwell for two reasons: The first reason was the physical dimensions of the mini-tablet. The mini-tablet screen size is 4" x 7"; the device weighs 10oz. (285 grams), and is only slightly larger than the largest available cell phone. It was thought that the larger screen would be preferable based on the amount of information in large font that could be presented at one time. The second reason we chose the mini-tablet cost. The price of a tablet computer is significantly less than that of a cellular phone.

An initial version of ASSISTwell was created by undergraduate college students in a Software Engineering course, to run on Android mini-tablets. This prototype served as an example for the focus groups. The prototype version of the software consisted of two applications (apps) for the Android tablet. One app was for the provider, and the other for the older adult user. Providers chose which surveys, health monitors, and medications the client needed, and the intervals at which these tasks would be completed. This "profile" was then transferred to the device of the older individual on a microSD card.

The central portion of the user interface is a list of the activities scheduled for today. The list is active, in that the user can touch an element to perform the indicated action. Data about any action taken is recorded and saved. ASSISTwell reminds the user to perform actions at the scheduled time if the user has not already performed them. For example, the application can remind the user that it is time to take a particular medication; the reminder persists until the user chooses "Skip" or enters the value or amount taken. In the case of

medications, the user can enter the exact amount of the medication taken; in the case of surveys the app will start asking the survey questions; in the case of physical health monitors, the app will ask for the value(s). ASSISTwell can remind the user to use their blood pressure cuff or glucose monitor and enter that data into ASSISTwell. The user can use this saved data to evaluate trends over time.

Two types of focus groups were held. During step three, two focus groups of older individuals, referred to here as end users were conducted. A total of 14 older women participated in two the groups, there were no male participants. The focus group for providers (Step Four) was comprised of eight nurses whose practice was focused on older adults transitioning from the hospital to home or living in the community. For each group, participants gathered at the appointed time and suitable refreshments were served. Groups were held in the afternoon at a senior center and an independent living facility for older end users, and in the evening at the College of Nursing for nurses (providers). The gerontological nurses and the computer scientist led the focus groups. Following initial introductions, the principal investigator introduced herself and the members of the research team present. The purpose of ASSISTwell was presented and the prototype was demonstrated. Each participant had a tablet device with ASSISTwell loaded on it so the users (older adults and nurses) could use ASSISTwell and comment on the functions. In addition to audiotaping and later transcribing the group interaction, an easel, and large paper were used to keep track of the groups' responses and major ideas.

Immediately following each focus group, the principal investigator and the members of the research team that were present for the focus group met to review the session and to enhance and clarify the data by adding their observations of the event to the data. This post focus-group analysis was also recorded for review during the synthesis process. Following the focus groups and the review session, a comprehensive summary of the focus group was generated. This process was repeated for each focus group. Three themes were identified in the focus group findings: users, user interface, and design suggestions. The findings from the focus groups were used to revise the use cases developed in step one and subsequently the design of ASSISTwell, and presented below.

Older adult end users

It was critical that older focus group participants should be representative of the older population in terms of their sensory-motor and cognitive capabilities. Two focus groups of older end users were conducted. Each focus group lasted for about an hour. During these focus groups, computer tablets with the prototype of ASSISTwell configured for sample users were given to the participants. We asked the participants to use the technology and comment on various aspects of the design of the older user application. They were not asked about the configuration side of the program. Data from these groups influenced the size of text and user interface controls (e.g., buttons, menu items), and the potential use of multiple modalities for both input and output (i.e., text and audio/speech).

Users

Overall participants in both focus groups of older individuals were positive regarding the existence of ASSISTwell. One participant said, "I think it is a good idea for tracking information, appointment keeping, and record keeping. I do not want to carry this device around having to be connected to it all the time, but it is very organizational. It may be very useful for different kinds of information collection".

Several participants thought the device was a good idea "for those people who needed something like this," but did not think that they needed this sort of thing. One participant, who had a very specific short-term memory deficit, repeatedly stated that it would be useful to people with memory issues like hers. Another person suggested it would be useful for individuals who had recently been ill or had just returned home from the hospital. Also, they agreed that they knew people who could not benefit from ASSISTwell because they were not independent enough.

Participants responded positively to the opportunity to allow family and friend access to data. They liked the idea that the older individual could have control over who was monitoring their data and that they could select who would have access. They also liked the possibility of allowing healthcare providers to have remote access to the data.

User Interface

Participants responded positively to the look of ASSISTwell including the colors and font size. One participant suggested that as people's eyesight began to fail there might need to be more contrast between the foreground and background, and regularized screens so similar questions were asked the same way, i.e. 'yes' being the top response, 'no' being the second response. Those participants who had had little computer contact were able to use ASSISTwell with minimal prompting. All but one participant found the touchscreen easy to use. One participant had considerable trouble mastering the art of 'swiping.' The participants commented that it would be good to minimize the number of clicks for each activity. One area of slight confusion was the way the program returned to the calendar, the main

user interface. Once an action was completed and the user indicated that they had completed the item it disappeared from the calendar. This happened rapidly and was hard for some participants to follow the action. They asked if the program could include zoom capability to change the size of the content on the screen.

Most but not all found the alarms helpful. Several participants had trouble remembering a particular activity and would like that activity alarmed. There was a discussion about which sounds would be best, and how long an alarm should ring before it automatically shut off. All agreed that the ability to select the sounds or to not use alarms at all be a user preference. There was also agreement that a voice speaking to the older end user would not be helpful.

Design features
Participants commented positively on the ability of the device to record and remind the end user to take medications. One participant commented that she cannot always remember if she took her pills earlier in the day. ASSISTwell would help her remember that she had accomplished various actions like taking her pills.

There were several comments regarding the Maintaining Balance Model. One participant was very concerned about the surveys for attitude, sense of control, and social function. She thought the surveys could be disturbing or disheartening. Another was concerned that ASSISTwell should make some response to negative answers. That simply recording information was not as useful as also providing some suggested action for negative responses. One participant wanted to program ASSISTwell with the questions and activities that were most useful to her. Another participant asked if ASSISTwell provided positive reinforcement, did it say "Good job!" when the user met their goals for the day.

The size and weight of the mini-tablet was a concern. Several participants commented that the device was heavy and would require them to carry a bigger purse to carry the tablet with them. Also, several participants routinely carry cell phones and they would not want to carry the cell phone and the tablet. They asked if ASSISTwell could be loaded onto a smart cell phone.

Participants suggested that ASSISTwell include an emergency feature. They suggested that there be some way to include a list of emergency contacts, and incorporate a way to contact them. This list could include family, friends, and healthcare providers. They also suggested that ASSISTwell might be configured to notify an emergency contact if the older end user did not use the device for 24 – 48 hours.

Participants suggested that there should be a way for the older individual or their family member to add their over-the-counter medications to the medication schedule. Some participants suggested that ASSISTwell be able to check on medication interactions when a new medication is added. The device would then notify the older end user that they should check with their provider or pharmacist before beginning the new medication.

The graph feature was well received. The older end users liked the idea that they could select which data could be easily displayed. The participants suggested data be available for up to three months, so they could track function over time.

Nurses
Eight registered nurses including discharge planners and home care nurses were recruited to engage in a focus group with the design team to help develop the part of the application that will be used by the person who configures the individualized self-management plan. This part of the ASSISTwell is menu driven; the nurse can select which interventions will be available to the older adult. The nurses engaged in a focus group where they programmed ASSISTwell, provided feedback about the program and made suggestions to improve utility. The focus group was audio recorded and transcribed.

There was some discussion regarding the cost of a mini-tablet computer. The nurses suggested that ASSISTwell be versatile enough to be programmed on existing smart phones and tablet devices. It was suggested that the tablet might be issued as telehealth equipment is currently issued for visiting nurse clients.

Users
Overall the nurses were open to the idea of older individuals using ASSISTwell to self-manage their health conditions. They could immediately see how ASSISTwell could help them provide better care for their older clients. Their agreement was summarized in the statement: "I think that many patients would really appreciate having ASSISTwell." One hospital case manager thought that ASSISTwell would be very useful for discharge instructions. She envisioned being able to configure the device with all discharge activities, including medications, exercises, diet, etc. so the client had all of the information in one place without having a volume of paper instructions. The nurses commented that the most likely population to benefit from using ASSISTwell were those older individuals who had multiple chronic conditions and were able to self-manage their symptoms with or with help from another person. For individuals

who lived at home and were receiving assistance from family and/or paid care providers, the technology may be useful for their care providers or family members. One nurse commented that in addition to older individuals, her practice included several clients in their 20s, 30s, 40s, and 50s who might benefit from using ASSISTwell.

The nurses commented positively on the possibility that for older individuals who were not using nursing services, the older individual's family members might configure the device, and informal care providers might use the technology to maintain a plan of care for an older person. One nurse said: "One client I work with has a computer tablet. Right now, she keeps her medication list on the refrigerator and every time it changes, I take the list to the doctors and ask to make sure it is updated. To be able to update the list from a distance, or to be able to send it to the primary care provider would be a huge help, I think, for her."

User interface

The nurses were positive about the overall design of ASSISTwell including the screen colors, font size, simplicity of language and ease of use. Some nurses thought the touchscreen may be a barrier to some older individuals. They were concerned that peripheral neuropathies, arthritis, and palsies may affect the older individual's ability to manipulate the information on the screen. They approved of the calendar that listed all tasks sequentially for the day. Although they supported the idea that the tasks disappear from the calendar as they were completed, they suggested that there be an easy way for the older individual to see what had already transpired during the day, and perhaps the previous day or month.

Design features

The nurses configured the device for possible clients based upon their clinical experience. They found the application to be easy, if somewhat tedious to configure. They requested that the process of configuration be completed with as few clicks and key strokes as possible. For example, they asked for a pull-down menu for the most frequently used medications rather than having to type in the name, dose, route, etc. Also, they requested that a balance be achieved between the number of screens needed to scroll through to find information and the amount of information on each page. They suggested that there be protection between the older end user side of the application and the configuration side of ASSISTwell. This would be to protect the users from accidentally deleting configured information. Finally, the nurses asked for complete documentation of ASSISTwell to be provided online at an easily accessible website.

Several suggestions were made for extensions to ASSISTwell. One nurse suggested that programs such as the NIH National Institute on Aging exercise program be loaded into the tablet and that ASSISTwell be able to access the program with a click of a button. Other nurses suggested that the device be able to respond to the older end user's social status by connecting the individuals to family and friends seamlessly through other tablet applications.

There was a lively discussion regarding access to the data. The nurses suggested that, with permission of the user, data be available to a wide variety of care providers including family members and primary care providers, home care nurses, etc. They suggested that care providers and family members, with the older user's permission, be able to use the internet to access the data from a distance. In this way, ASSISTwell could become a communication device to make sure the older individual was following their daily schedule, and alert individuals at a distance to possible deviations from normal behavior as soon as they occur.

In addition to distance monitoring, the nurses suggested that it might be useful if the device could be configured from a distance. This would be particularly useful for visiting nurses who might have medication changes to configure. Also, the nurse might be able to add his or her visit to the daily schedule. With respect to distance access one nurse said: "If you had their permission and you were able to log in from a distance, you could configure changes for them. They would appreciate the alarm, would appreciate being able to look and clearly see what they were to take."

The nurses commented on the utility of ASSISTwell beyond a self-management device to assist care providers in maintaining a plan of care. They suggested that the ability for unlicensed care providers, such as homemakers and home health aides, to document or sign for care be a feature of ASSISTwell. They also thought it would be useful if data from ASSISTwell could be incorporated into an individual's electronic health record.

In order to make ASSISTwell maximally useful for helping older individuals manage their health and achieve optimal wellness, the nurses suggested that there be a way for the older individual's advanced directives to be included, so that, in the event of an emergency, all of the older individual's health data would be easily located in one place.

Following the focus groups, the software was rewritten based on the use-cases mentioned above and the feedback from the focus groups. The rewritten version combined the provider app and the client app into a single application as suggested by the providers (*Figure 1 & Figure 2*).

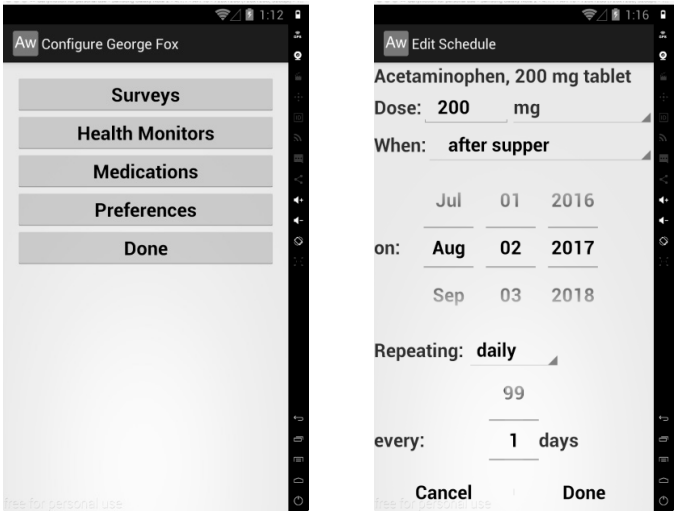

Figure 1. Screenshot of provider interface screen

The rewritten version was developed for the Android platform, written in Java, and completely replaced the student version. The code was revised iteratively to eliminate inconsistencies and errors, resulting in a correctly functioning algorithm. The app was written to use standard Android features wherever these were available; for example, it uses the standard Android reminder feature. It was targeted to a minimum version (16) of the Android system to maximize the number of devices on which it can run. This technique led to remarkably stable code. The ASSISTwell app is currently undergoing additional testing and there have been no bugs or crashes noted thus far. It has been tested on mini-tablets, but should be easily ported to other Android devices; the app makes very few assumptions about the exact capabilities of the device. The choice of Android was a choice of convenience, eventually, there will be a version of ASSISTwell that will run on the iOS platform.

The app is currently stand-alone, with no communications with other devices. It uses neither WiFi nor Bluetooth. The version under development will support Bluetooth communication between instances of the app on different devices, and it is planned that it will support Bluetooth communication with compatible health-monitoring devices, such as glucose monitors.

Following further revisions of ASSISTwell, community-dwelling older adults who are living with chronic illness will evaluate its functionality, effectiveness, and overall usability in their own environment and in the context of their daily lives. The design and user interface will be modified based on user feedback and the second round of evaluation will then be performed with the modified prototype. Following these tests, ASSISTwell will be evaluated with respect to improving health outcomes for older individuals who are living in their own homes and self-managing multiple chronic conditions.

Discussion

The development process involved iterative refinement of the ASSISTwell application; starting with a simple prototype that tested the basic functions of ASSISTwell and the layout of the interface. As work progressed, the application and the user interface became progressively more complex eventually producing the full-scope application. The focus group findings informed design decisions at every step of development.

Our system is innovative in that it is based on supporting self-management and functional ability through a theoretically based intervention, not on a particular disease process. This approach will be useful to a wide spectrum of older adults who are living with multiple chronic conditions. In a recent scoping review of computer systems for self-management of chronic conditions, it was found that of the 30 self-management systems reviewed, only five were useful for individuals with more than one chronic condition13. Unlike other types of health technology, our device is focused primarily on improving self-management by the individual, not surveillance by health-care providers. We developed a computer program designed specifically for older individuals with multiple chronic conditions that runs on a portable, relatively inexpensive technology, mini tablet computers, with a popu-

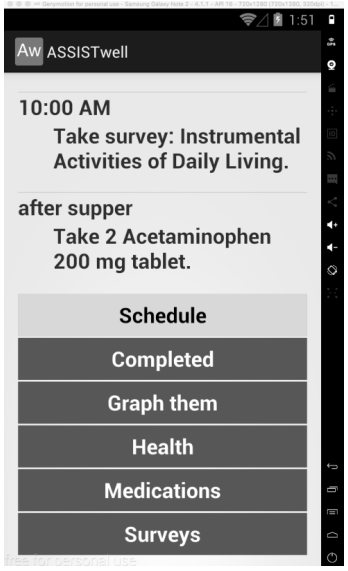

Figure 2. Screenshot of older adult user interface

has been thought to be reluctant to use computers. Finally, the research team is innovative in that it is a transdisciplinary team which includes nurses, computer scientists, and engineers.

We developed an innovative mini-tablet-based application (ASSISTwell) to enhance older adults' self-management of symptoms of multiple chronic conditions. ASSISTwell was based on the functional approach described above. The system is designed to be used within the context of the older individual's daily life and support their actions to achieve optimal wellness, and improve communication between the individual and his or her healthcare provider about daily self-management practices. ASSISTwell is an easy to use, tablet-based interactive program. ASSISTwell can (1) prompt the user to engage in healthful behaviors; (2) respond to the user's interactions by recording, integrating, processing, analyzing, and displaying health-related information in a way the that is useful to the user[44]; and (3) store and display longitudinal data for feedback on health behaviors and goal attainment to the older adult and to their healthcare providers to review health behaviors. ASSISTwell preserves the privacy, dignity, and autonomy of older adults and provides control over their health information to allow or deny access by other people.

The next step in developing ASSISTwell is to test the device with a group of older individuals who have chronic conditions. We plan to conduct a study in which older individuals use ASSISTwell for one month and gather data regarding user satisfaction and actual use data from the device. Following this study, ASSISTwell will be revised based on the findings and then we will test the efficacy of the app with a large group of older individuals using outcome measures which will indicate if using ASSISTwell improves health outcomes.

Conclusion

Developing technologies to help aging people manage their multiple chronic diseases is critical to controlling healthcare cost and promoting independence. Using an iterative approach, we have developed ASSISTwell to provide self-management support to older individuals with multiple chronic conditions. Older individuals and nurses who participated in focus groups responded positively to the prototype computer application and their comments made a significant difference in the development of the final project. They made suggestions regarding the user interface and functions of the application. As a result, ASSISTwell is a computer application which is designed specifically for older users. It incorporates simple, clear, and easy-to-read fonts and colors to provide reminders and feedback to older users about five aspects of their daily lives. With the permission of the older user, data can be transferred from the application to the provider's health record. ASSISTwell was designed to help older individuals with multiple chronic conditions manage their health holistically to help them achieve optimum wellness within the context of their daily lives. Our unique development approach is a model for other software developers.

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References

1. PARTNERSHIP FOR SOLUTIONS. Chronic conditions: making the case for ongoing care 2004; http://www.partnershipforsolutions.org/; retrieved January 25, 2014
2. Healthy aging. Chronic disease prevention and promotion. https://www.cdc.gov/chronicdisease; retrieved December 20, 2017
3. National Institute on Aging. FY 2017 Director's Overview; https://www.nia.nih.gov/about/budget/fy-2017-justification-budget-request/fy-2017-directors-overview; retrieved December 20, 2017
4. Vogeli C, Sheilds AE, Lee TA, Gibson TB, Marder WD, Weiss KB, and Blumenthal D. Multiple chronic conditions: Prevelance, health consequences, and implications for quality, care management, and costs. Journal of General Internal Medicine 2007;22:391-5; https://doi.org/10.1007/s11606-007-0322-1
5. Jacelon C. Maintaining the balance: Older adults with chronic health problems manage life in the community. Rehabilitation Nursing Journal 2010;35:16-32; https://doi.org/10.1002/j.2048-7940.2010.tb00026.x
6. Schulman-Green D, Jaser S, Martin F, Alonzo A, Grey M, McCorkle R, Redeker NS, Reynolds N, Whittemore R. Processes of self-management of chronic illness. Journal of Nursing Scholarship 2012;44:136; https://doi.org/10.1111/j.1547-5069.2012.01444.x
7. Spector W, Mutter R, Owens P, Limcangco R. Transitions between nursing homes and hospitals in the elderly population 2009. HCUP Statistical Brief #141: Agency for Healthcare Research and Quality, Rockville, MD.; 2012. PMID: 23136674
8. Foundation RWJ. Partnership for Solutions. Chronic conditions: Making the case for ongoing care 2002. http://www.rwjf.org/en/research-publications/find-rwjf-research/2010/01/chronic-care.html; retrieved December 19, 2017
9. Erdem E, Korda H. Self-Management program participation by older adults with diabetes. Family & Community Health 2014;37(2):134-136; https://doi.

org/10.1097/FCH.0000000000000025
10. Saiyed K, Vines D, Stein B, Mosnaim G. The use of Asthma Blues (c) educational program and device teaching to improve asthma knowledge and self-management skills. Respiratory Care Educational Annual 2013;22:45-48
11. Radhakrishnan K, Jacelon C, Roche J. Perceptions on the use of telehealth for heart failure by homecare nurses and patients: A mixed method study. Home Health Care Management and Practice 2012;24(4):175-181; https://doi.org/10.1177/1084822311428335
12. Society CoaA. Disease management programs: Improving health while reducing costs? Washington, DC: George University; 2004
13. Jacelon C, Gibbs M, Ridgway J. Computer technology for self management: A scoping review. Journal of Clincal Nursing 2016;23:1179-1192; https://doi.org/10.1111/jocn.13221
14. Villalba E, Salvi D, Peinado I, Ottaviano M, Arredondo M. Validation results of the user interaction in a heart failure management system. International Conference on eHealth, Telemedicine, and Social Medicine: IEEE; 2009:81-86
15. Triantafyllidis A, Velardo C, Shah SA, Tarassenko L, Chantler T, Paton C, Rahimi K. Supporting heart failure patients through personalized mobile health monitoring. International Conference on Wireless Mobile Communication ans Healthcare Transforming healthcare through innovations in mobile and wireless technologies: ICST; 2014;287- 290
16. Rosser B. Promoting self-management through technology: SMART solutions for long-term health conditions. Journal of Integrated Care 2009;17:10-19; https://doi.org/10.1108/14769018200900041
17. Maglaveras N, Maglavera S, Lekka I, Chouvarda I, Kainakamis V, Kilintzis V, Prentza A. Quality home telemedicine services for chronic cardiac disease patients through the INTERLIFE Platform. Computers in Cardiology 2006;33:245-248
18. Finkelstein J, Wood J. Introducing home telemanagement of congestive heart failure using Xbox gaming platform. 24th International Conference on Computer based Medical Symptoms: IEEE; 2011
19. Cha E, Wood J, Finkelstein J. Using gaming platforms for telemedicine applications: A cross-platform comparison. IEEE_EMBS International Conference on Biomedical and Health Informatics. Hong Kong & Shenshen, China: IEEE; 2012
20. Burns W, Davies R, Nugent C, McCullagh PJ, Zheng H, Black ND, Mountain GA. A personalized self-management system for chronic heart failure. Computing in Cardiology 2010;37:1075-1078
21. Brennan P, Casper G, Burke L, Johnson KA, Brown R, Valdez RS, Seburn M, Perez OA, Sturgeon B. Technology-enhanced practice for patients with chronic cardiac disease: Home implementation and evaluation. Heart & Lung 2010;Nov/Dec:S34-S46; https://doi.org/10.1016/j.hrtlng.2010.09.003
22. Abraham IL, Bottrell MM, Dash KR, Fulmer TT, Mezey MD, O'Donnell, L, Vince-Whitman C. Profiling care and benchmarking best practice in care of hospitalized elderly. Geriatric institutional assessment profile. Nursing Clinics of North America 1999;34:239-255
23. Austin L, Landis C, Hanger K. Extending the continuum of care in congestive heart failure: An interactive technology self-management solution. Journal of Nursing Administration 2012;42(9):442-446; https://doi.org/10.1097/NNA.0b013e3182668342
24. Farmer A, Toms C, Harding M, Williams V, Rutter H, Tarassenko L. Self-management support using an Internet-linked tablet computer (the EDGE platform)-based intervention in chronic obstructive pulmonary disease: protocol for the EDGE-COPD randomised controlled trial. British Medical Journal Open 2014;4; https://doi.org/10.1136/bmjopen-2013-004437
25. Nguyen H, Donesky D, Reinke L, Wolpin S, Chyall L, Benditt JO, Paul SM,Carrieri-Kohlman V. Internet-based dyspnea self-management support for patients with chronic obstructive pulmonary disease. Journal of Pain and Symptom Management 2013;46:43-55; https://doi.org/10.1016/j.jpainsymman.2012.06.015
26. Pinnock H, Hanley J, McCloughan L, et al. Effectiveness of telemonitoring integrated into existing clinical services on hospital admission for exacerbation of chronic obstructive pulmonary disease: researcher blind, multicentre, randomised controlled trial. BMJ 2013;online open access:16
27. Tabak M, Brusse-Keizer M, vanderValk P, Hermens H, Vollenbroek-Hutten M. A telehealth program for self-management of COPD exacerbations and promotion of an active lifestyle: a pilot randomized controlled trial. International Journal of COPD 2014;9:935-944; https://doi.org/10.2147/COPD.S60179
28. Arshad F, Wallymahmed, Dabhi S. Diabetes online - Patient management. (PO-PM). 2009 Second International Conference on Developments in eSystems Engineering: IEEE Computer Society; 2009
29. Carter E, Nunlee-Bland G, Callender C. A patient-centric, provider-assisted diabetes telehealth self-management intervention for urban minorities. Perspectives in Health Information Management 2011
30. Farmer A, Gibson O, Hayton P, Bryden K, Dudley C, Neil A, Tarassenko L. A real-time, mobile phone-based telemedicine system to support your adults with type 1 diabetes. Informatics in Primary Care 2005;13:171-177
31. Fioravanti A, Fico G, Arredondo M, Leuteritz J. A mobile feedback system for integrated e-health platforms to improve self-care and compliance of diabetes mellitus patients. 33rd Annual International Conference of IEEE EMBS. Boston Massachusetts 2011
32. Istepanian R, Sungoor A, Earle K. Technical compliance consideration for mobile health self-monitoring of glucose and blood pressure for patients with diabetes. 31st Annual International Conference of the IEEE EMBS. Minneapolis, MN: IEEE; 2009
33. Manousos D, Chiarugi F, Kontogiannis V, Karatzanis I, Kouroubali A, Spanakis EG, Marias K, Fursse J, Thomson S, Jones RW, Verma V, Clarke M. First results about the use of a patient portal by people with diabetes in a rural area. The 4th IEEE International Conference on E-Health and Bioengineering - EHB 2013. Grigore T Papa University a/Medicine and Pharmacy, Ia§i, Romania,: IEEE; 2013
34. Nes A, vanDulmen S, Eide E, Finset, A, Kristjandottir OB, Steen IS, Eide H. The development and feasibility of a web-based intervention with diraies and

situational feedback via smartphone to support self-management in patients with diabetes type 2. Diabetes Research and Clinical Practice 2012;97:385-393; https://doi.org/10.1016/j.diabres.2012.04.019
35. Roblin D. The potential of cellular technology to mediate social networks for support of chronic disease self-management. Journal of Health Communication 2011;16:59-76; https://doi.org/10.1080/10810730.2011.596610
36. American Telemedicine Association. 2006/2007. http://www.americantelemed.org/; retrieved January 11, 2008
37. Burkow T, Vognild L, Krogstad T, Borch N, Ostengen G, Bratvold A, Risberg MJ. An easy to use and affordable home-based personal eHealth system for chronic disease management based on free open source software. In: al. ASe, editor. eHealth Beyond the Horizon - Get IT There; 2008: IOS Press;83-88
38. Davies R, Galway C, Nugent C, Jamison RE, Gawley RE, McCullagh PJ, Zheng H, Black, ND. A platform for self-management supported by assistive, rehabilitation and telecare technologies. 5th Annual Conference on Pervasive Computing Technologies for Healthcare (PervasiveHealth) and Workshops: ICST; 2011
39. Gabrielian S, Yuan A, Andersen R, McGuire J, Rubenstein L, Sapir N, Gelberg L. Chronic disease management for recently homeless veterans: A clinical practice improvement program to apply home telehealth technology to a vulnerable population. Medical Care 2013;51:S44-S51; https://doi.org/10.1097/MLR.0b013e31827808f6
40. McCusker, J, Cole, M, Yaffe, M, Sussman, T, Lavoie, KL, Strumpf, E, Sewitch, M, Sahin, D, deRaad, M. A feasibility study of a telephone-supported self-care intervention for depression among adults with a co-morbid chronic physical illness. Mental Health in Family Medicine 2012;9:257-273
41. Toh S, Lee S, Chung W. WSN based personal mobile physiological monitoring and management system for chronic disease. Third 2008 International Conference on Convergence and hybrid information technology: IEEE; 2008
42. Seibert P, Whitmore T, Patterson C, Parker PD, Otto C, Basom J, Whitner N, Zimmerman CG. Telemedicine facilitates CHF home health care for those with systolic dysfunction. International Journal of Telemedicine Applications 2008; https://doi.org/10.1155/2008/235031
43. de Lusignan S, Wells S, Johnson PR, Meredith K, Leatham E. Compliance effectiveness of 1 year's home telemonitoring the report of a pilot study of patient with chronic heart failure. European Journal of Heart Failure 2001;3:723-730; https://doi.org/10.1016/s1388-9842(01)00190-8
44. Or C, Karsh B, Severtson D, Burke L, Brown R, Brennan P. Factors affecting home care patients' acceptance of a web-based interactive self-management technology. Journal of the American Informatics Association 2011;18:51-59; https://doi.org/10.1136/jamia.2010.007336
45. Aguilar A, Boerema C, Harrison J. Meanings attributed by older adults to computer use. Journal of Occupational Science 2010;17:27-33; https://doi.org/10.1080/14427591.2010.9686669
46. Jacelon C, Hanson A. Older adults' participation in the development of smart environments: An integrated review of the literature. Geriatric Nursing 2013;34:116-121; https://doi.org/10.1016/j.gerinurse.2012.11.001
47. WHO. World Report on Disability. Geneva, Switzerland: WHO Press; 2011
48. Hebda T, Czar P. Handbook of informatics for nurses & healthcare professionals. 5th Ed. ed. Boston: Pearson; 2013
49. Sharp H, Rogers Y, Preece J. Interaction design: Beyond human-computer interaction. 2nd ed. New York: John Wiley & Sons, Inc; 2007
50. Krueger R, Casey M. Focus groups: A practical guide for applied research. 4th ed. Thousand Oaks, CA: Sage; 2009