Mobile App Design for Veterans with Physical and Cognitive Limitations

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ABSTRACT

Pressure ulcers are a significant cause of morbidity and mortality among hospitalized, institutionalized, and mobility-compromised Veterans, and the prevalence of pressure ulcers has been an ongoing challenge for the U.S. Department of Veterans Affairs (VA). With the VA currently serving World War II- through Post-911-era Veterans with Service-, age-, and illness-related physical and cognitive limitations, the VA sought an innovative solution to educate and support the full spectrum of Veterans at risk of developing pressure ulcers. They selected the VA Pressure Ulcer Resource (VAPUR) project to design a hybrid Mobile Application (App) providing this "just-in-time" education and performance support for Veterans and their Caregivers.

In addition to educational content structured as frequently asked questions with graphics and videos, the App allows Veterans to securely self-report wound data to the VA using a simply worded form. This reporting capability enhances the VA's ability to monitor Veterans who live too far from specialized wound care facilities to get regular pressure ulcer care. The App supports Veterans with cognitive limitations by automating functions like setting reminders for daily tasks, dialing help and locating resources, and communicating with medical providers. The VA Human Factors Team tested the App with Veterans to ensure usability heuristics and industry-wide standards were focal points in the design. The VA Section 508 Accessibility Team also tested the App to ensure it optimizes the accessibility features in current operating systems and fully complies with all Section 508 requirements.

Because standard App interfaces and traditional educational approaches were insufficient for the diverse target audience, this paper discusses the unique human-computer interface design considerations made for users with physical and cognitive limitations. It also discusses how the resulting design can be reused for other Apps, particularly for conditions like COPD, heart disease, and diabetes. VAPUR will be deployed in August 2015.

ABOUT THE AUTHORS

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Lea G. Blake is a Business Systems Analyst and Instructional Designer at Serco with more than 20 years of experience in IT, training, adult education, web design and data management. She is a content designer and developer on the VAPUR project. Lea served in the U.S. Air Force from 1976-1985 and was honorably discharged as an E-5.

Devin Harrison is a Management Analyst in the Veterans Affairs Center for Innovation (VACI) and the VAPUR project manager. He has over 10 years of experience in project management and engineering. Devin manages projects for the VACI Veterans Health Administration Industry Innovation Competition that spark creative thinkers and companies to create new ideas, fresh perspectives, and different approaches to how the VA operates and cares for Veterans. The four Industry Competitions held to date have generated over 800 ideas resulting in over 40 projects that are in various stages of design, development, testing, and evaluation.

William Plew is a Usability Specialist in Human Factors Engineering (HFE) at the VA. His work primarily focuses on participant studies and heuristic evaluations for Veterans Health Administration mobile applications and websites. He was also the lead analyst assessing tools for potential use by the HFE team. William received his M.S. from Embry-Riddle Aeronautical University in Daytona Beach, FL. He also has extensive experience with simulation environments and hopes to see them integrated into the VA to optimize workflows and layouts for VA facilities.

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INTRODUCTION

The U.S. Census Bureau indicated about 56.7 million people, 19 percent of the population, had reported a disability under a broad definition of disability that included difficulties with hearing, vision, cognitive, ambulatory, self-care, and independent living functions. More than half reported the disability was severe (U.S. Census Bureau, 2012).

The World Wide Web Consortium (W3C) classifies physical disabilities as weakness, limited muscular control (involuntary movements, tremors, lack of coordination, or paralysis), limited sensation, joint problems (such as arthritis), pain that impedes movement, or missing limbs. People with physical disabilities may use specialized hardware and software to interact with mobile technology including head pointers, styluses, and other aids to help typing; voice recognition; and other approaches for hands-free interaction (W3C, 2015). The W3C reports common usage issues for people with physical disabilities include difficulty selecting small areas or typing. As a result, designing technology solutions with large selectable areas is critical. The W3C suggests users with physical disabilities benefit from features that simplify data entry such as forms with selectable lists and visible indicators showing the current focus. Many of these recommendations are shared by individuals with cognitive, neurological, and visual disabilities (W3C, 2015).

According to the W3C, technology users with cognitive disabilities need clearly structured content that facilitates overview and orientation and standardized and consistent forms, buttons, content parts, and labels. Predictable functionality and behavior makes it easier for them to interact with the technology. Likewise, the W3C recommends providing different ways to navigate through information and using simple text supplemented by images. People with cognitive disabilities also use assistive technologies including text-to-speech software and tools that resize text and spacing, simplify grammar and spelling, and customize colors for readability.

"Like most Americans, many people with disabilities consider their mobile device to be an indispensible tool in their everyday lives. Nearly 90 percent of American adults have a mobile device, and 85 percent of Americans with disabilities reported wireless device ownership in 2007" (Mobile Future, 2010, p. 8). Mobile technology can transform the lives of individuals with disabilities, but standard interfaces and approaches are often insufficient to meet the range of issues faced by individuals with physical and cognitive limitations. This paper discusses the human-computer interface considerations made in a mobile application designed for Veterans with physical and cognitive limitations who are at high risk of developing pressure ulcers. It includes lessons learned and discusses how the resulting content and architecture can be reused for other Apps, particularly for conditions like chronic obstructive pulmonary disease (COPD), heart disease, and diabetes.

BACKGROUND

The Veterans Health Administration is the U.S.'s largest integrated health care system with over 1,700 care sites, serving nearly nine million Veterans yearly (VA, 2015b). According to a 2008 CBS News Report, the number of disabled Veterans has jumped by 25 percent since 2001 to 2.9 million or about 26 percent of the Veteran population (Census Bureau, 2013). Having a physical disability puts Veterans at an increased risk of developing a pressure ulcer. Pressure ulcers are a significant cause of morbidity and mortality among hospitalized, institutionalized, and mobility-compromised individuals (VA, 2012, p. 9).

Veterans with pressure ulcers require attention from a wound care specialist for skin assessment and treatment. Access to specialists can be difficult for Veterans in rural areas (VA, 2012, p. 9). According to the Official VA Blog

(2015a), 3.2 million Veterans currently enrolled at the VA live in rural locations. Rural communities face unique barriers to care including transportation, access to providers, and limited broadband coverage. Outpatient clinics may not be able to address the needs of pressure ulcer patients. Sending them for treatment at distant VA facilities or non-VA medical centers can involve significant travel and result in discontinuity of care (VA, 2012, p. 9).

VHA Handbook 1180.02, Preventing Pressure Ulcers (2011, p. 8) states “A Veteran with a pressure ulcer or at risk for developing a pressure ulcer, along with the Veteran’s family members, surrogates, or authorized decision makers, must be appropriately educated so as to enable active participation in prevention and treatment decisions.” The educational programs and materials must be relevant to their education level, motivate them to take responsibility for maintaining healthy behaviors, encourage them to participate, and seek positive outcomes or changes in behaviors. To support this requirement, a 2012 Broad Agency Announcement (BAA) released through the VA Innovation Initiative (VAi2) Industry Innovation Competition, sought

> proposals that provide a comprehensive approach to pressure ulcer prevention, including innovation in the content and delivery of training for both staff and patients. The treatment of pressure ulcers is greatly improved by the collection and tracking of clear, accurate, and consistent information throughout the continuum of care. The ability to track individual wounds, capturing such information as wound etiology, accurate and standardized staging, and quantified and standardized data on wound healing is of fundamental importance. Clinicians, home caregivers, and patients themselves may collect this information in a variety of inpatient, outpatient, and home health settings. (VA, 2012, p. 9)

Veteran Population

The VA currently serves Veterans from World War II through the present period. These Veterans have varying levels of education, experience, and exposure to technology, making a single educational solution difficult. Disabled Veterans also have a wide range of Service-, age-, and illness-related physical and cognitive limitations that may include one or more of these:

- Spinal cord injury such as monoplegia, paraplegia, tetraplegia,
- Amputation,
- Neurological degeneration such as multiple sclerosis (MS) or amyotrophic lateral sclerosis (ALS),
- Cognitive limitations such as those resulting from stroke, traumatic brain injury (TBI), or age,
- Auditory or vision loss, or
- Loss of mobility due to age.

Many Veterans with these limitations require assistance from a Caregiver to perform their daily living activities (bathing, eating, taking medications, et cetera). With the wide age range of Veterans, a Caregiver may be a parent, sibling, spouse, child, grandchild, or other loved-one or close friend. Caregivers range in ages and education levels and few have formal medical training. Many, particularly Caregivers of Post-911 Veterans, sent a healthy Service member on deployment and welcomed home a severely disabled loved-one who may also have reduced cognitive function resulting from a TBI received in conjunction with the injury sustained. So while many Caregivers had years to adjust to a declining health situation, these Caregivers were thrust into a new and unexpected role demanding physical strength, requiring medical support, and creating emotional stress.

Case Study

In response to the 2012 BAA, the VA Pressure Ulcer Resource (VAPUR) was developed as a suite of educational resources to meet the needs of the diverse Veteran audience. VAPUR includes standard- and large-font print aids for Veterans less adept at using technology, an educational DVD for Veterans with some level of technology exposure, and a mobile application (App) for more technology savvy users. VAPUR supports the VA’s goal of “getting to zero” for the prevalence of pressure ulcers. It was designed specifically for the pressure ulcer prevention and treatment needs of Veterans and their Caregivers, rather than medical professionals. This paper focuses on the VAPUR Mobile App as an interactive performance support tool.

HUMAN-COMPUTER INTERFACE (HCI) CONSIDERATIONS

Federal accessibility requirements under Section 508 of the U.S. Rehabilitation Act require technology solutions to meet accessibility requirements designed to support users with physical limitations. VAPUR was required to achieve 100 percent compliance with these standards. Because these standards were well defined and clearly prescribed (accessibility to screen reads, alternate tags for images, et cetera) they were relatively easy to achieve and will not be addressed here. However, the small size of mobile platforms necessitated additional design considerations for Veterans with physical limitations like spinal cord injuries (SCI) or tremors. Many of these users also have impaired fine motor skills that make selection of the smaller areas and buttons on a mobile device difficult, so the App was designed with large and forgiving selection areas. A significant amount of white space was placed between selection areas to minimize the potential for incorrectly selecting an area accidentally. Touch responsiveness was set to very high so that even light touches would be received as inputs. Breadcrumbs and back buttons allow users to quickly return to the previous page for error control in the event they input something incorrectly.

While accessibility for individuals with physical limitations is a requirement of Federal projects, few have applied HCI considerations to individuals with cognitive limitations, particularly across the range of age and education levels in the current Veteran population. As previously stated, many Veterans have cognitive limitations resulting from stroke, age, or TBI including difficulty remembering, problem-solving, and controlling behavior. Krug argues that the cardinal rule of usability is "Don't make me think!" (as cited in Mariger, 2006), so a significant focus of the App design was reducing cognitive load across all functions and tasks.

The App was written at a sixth-grade reading level and approved by VA subject matter experts (SMEs). Words and sentences were intentionally simple and succinct. Krug said reducing the number of words makes it easier to find information, and reduces the visual overload and scrolling which are key factors for individuals with cognitive limitations (as cited in Mariger, 2006), but also for individuals with physical limitations that make actions like scrolling more difficult. Three important usability factors measured during App testing were effectiveness (the accuracy and completeness with which users achieve specified goals), efficiency (the resources expended in relation to the accuracy and completeness with which users achieve goals), and satisfaction (freedom from discomfort, and positive attitudes towards the use of the product) (Harrison, et. al., 2013); however, only effectiveness and satisfaction are reported. This limitation is explained later in the paper. Each function in the App was designed and evaluated based on these core elements of summative usability testing. The following sections detail the special HCI considerations given to the App’s functionality to ensure it supported the needs of individuals with cognitive limitations.

Frequently Asked Questions

FAQs have been widely vetted for over 30 years and set the tone of the user’s interaction with the content. They allow “people to rule out most of the topics quickly, and then just read the parts that have something to do with the question at hand. Good information design in an FAQ can help people both locate what they need and discover other information they may want” (Farrell, 2014). The App uses FAQs to make the educational content feel more like a conversation with a caring medical professional than a formal experience. “Learn” gives users simple educational content with graphics and videos structured as frequently asked questions (FAQs) on topics ranging from pressure ulcer care to the role of nutrition and exercise in prevention and healing. In accordance with Mariger’s recommendations, material within each FAQ was “chunked” to one idea per paragraph (as cited in Mariger, 2006), and, using responsive design, each subtopic within a single FAQ was placed in a different colored, high-contrast text box to indicate a change in topic.

Each FAQ topic was arranged based on the frequency with which it was typically asked to reduce cognitive load and facilitate problem solving. SMEs helped determine the optimal order for each topic list. To ensure critical content was not missed, related educational content and tutorial videos were cross-referenced or linked so users could see the relationships between topics. For example, in the Pressure Ulcer topic, one of the questions is “Why is nutrition important?” The question is answered briefly on that page, and then a link allows users to “Learn About Nutrition” which opens the Nutrition FAQ topic and a more comprehensive set of FAQs.

According to Farrell, familiarity “is what makes interfaces seem intuitive and it can improve learnability” (Farrell, 2014). The FAQs in “My Journal” allow users to self-report descriptive information about a pressure ulcer via a standardized form with predefined response options. To reduce cognitive load and enhance understanding, the response options were (1) restricted to short lists to prevent cognitive overload, (2) written in simple, short descriptive text, (3) represented with images to simplify complex concepts (Mariger, 2006), and (4) predefined to make mapping the data on the VA side easier. Users were allowed to photograph the pressure ulcer and write free-form notes about it. Upon completion of a "My Journal" entry, users submit the encrypted form to the VA. Figure 1 shows the "Journal Entry" screen with its questions and the response option screens for two of the questions.

To ensure consistency of terminology and diagnoses and enable VA data analysis without impacting usability, each "My Journal" response option was mapped on the back-end to standardized medical terminology stored in a patient-generated database (PGB) at the VA. The mapped data used the Logical Observation Identifiers Names and Codes (LOINC), a universal medical coding system for documenting tests, measurements, and observations, and the Systematized Nomenclature of Medicine – Clinical Terms (SNOMED – CT), an electronic exchange of clinical health information. The data is intended to help wound care specialists better understand the pressure ulcer's state and changes to the pressure ulcer over time without seeing the individual in person. This is particularly beneficial to Veterans in rural locations who are not located near a VA care facility.

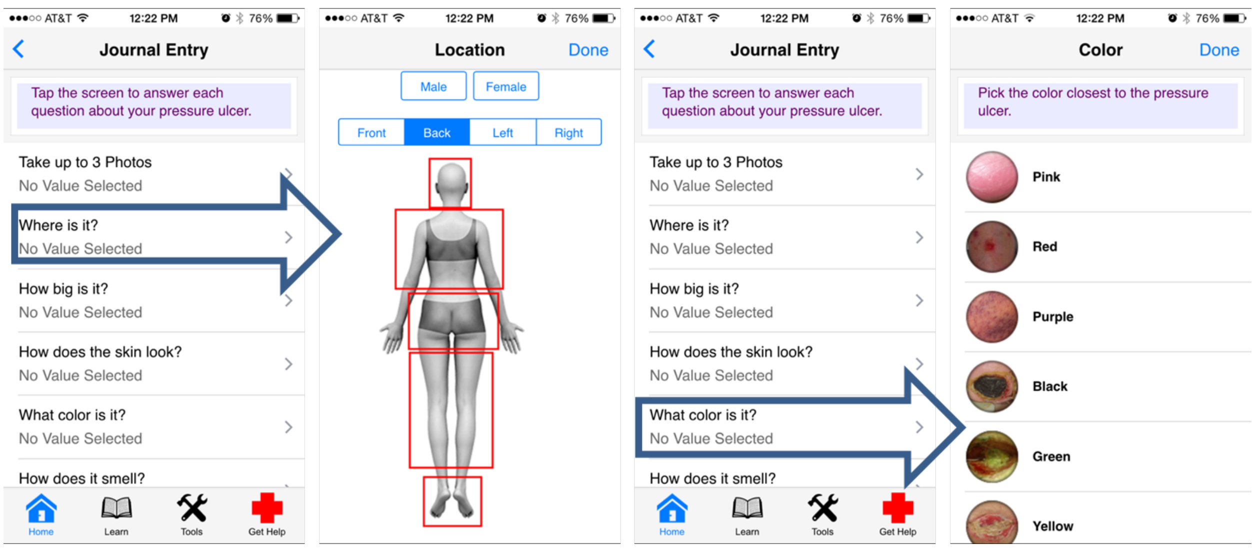

Figure 1. FAQ Use and Response Options in "My Journal"

Findability and Discoverability

While FAQs seem like an optimal solution to allow users to find and discover the answers to their questions about pressure ulcers, users with cognitive limitations may struggle with how to ask a question or with reading longer sentences used to formulate FAQs. Stroke victims in particular may be able to parse only single word descriptions. In addition, some users may think of terms or phrases that are buried deep within the answer to an FAQ. To combat this problem and ensure users with cognitive limitations could still find the information, "Find Symptoms and Causes" allows users to search an indexed set of terms and phrases covering the full range of "Learn" content. Users can enter a search term or scroll through the list of terms and phrases to find information.

Accordion Page Design

Since context for certain types of information is just as important as the information, accordions allow users to see "the big picture before focusing on details, can effectively mitigate the common problem of overly long pages" (Badiu, 2015), and were used in the App to display "Learn" content. In the wound care community, pressure ulcers are described by stage. Each stage relates to a varying degree of tissue damage, some easily visible, some not easily visible. Using an article targeted at clinicians, the stages of a pressure ulcer were described with an apple that goes from shiny with a bruise hidden under its skin in Stage 1 to the core of an apple where the "meat" was eaten away in Stage 4, the most severe pressure ulcer (Turner, 2013).

For the “Stages” FAQ shown in Figure 2, the accordion page was used to reveal additional information about each stage while the nearest apple image for each stage remained on screen to give the context. Within each stage, an additional accordion revealed photos of actual pressure ulcers in that stage. These accordions featured a warning icon and the statement *“Tapping here will show photos that may upset you”* because as the stages progress the photos become increasingly graphic and disturbing. According to the SMEs, showing the progression of actual pressure ulcers helps people understand how what was previously known as a “bed sore” could become a life-threatening medical condition. This also addresses Mariger’s recommendation to use “unexpected events” to help a person to retain information (as cited in Mariger, 2006).

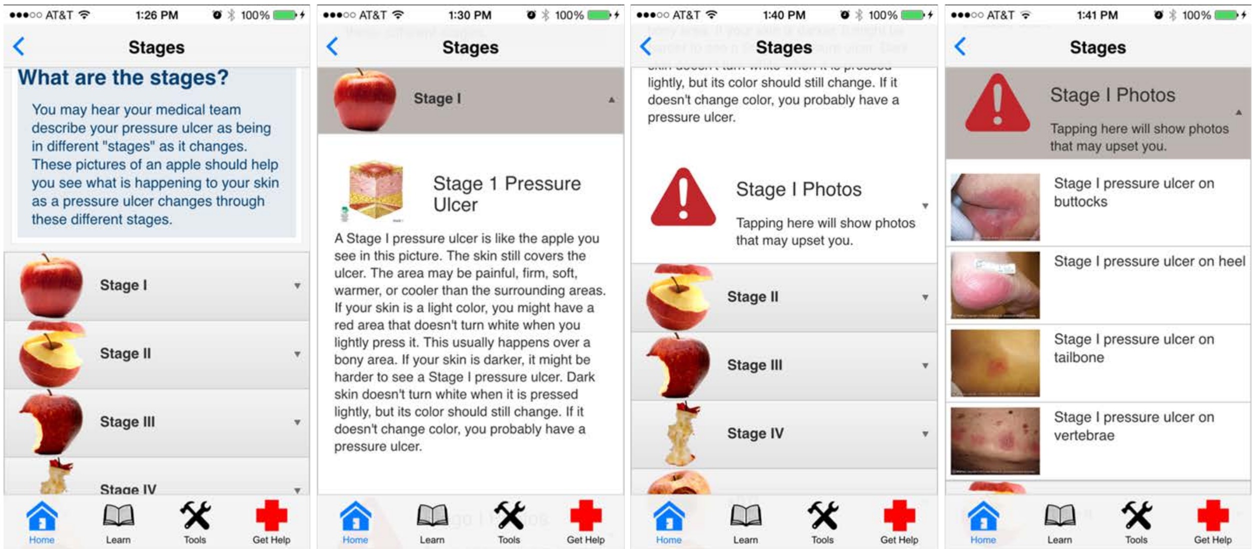

Figure 2. Panel Bar Design Template for “What are the Stages?”

Memory Prompts

Repositioning, the frequent changing of positions to shift weight from one area of the body to another, is a critical tool in the prevention and healing of pressure ulcers. Getting and keeping pressure off of an area is particularly problematic for people with physical limitations; however, adding a cognitive limitation to the physical limitation could cause a person to forget to reposition. Likewise, with nutrition being another key factor in pressure ulcer healing, Veterans may be instructed to snack every hour or two to ensure their caloric intake is sufficient to heal their wound. “Set Reminders” helps users offload the need to remember these tasks by completing simple forms with selectable options that are large and easy to read. Reminders are available for repositioning and eating a snack. Since Veterans with cognitive and physical limitations are also likely to be sleep-deprived, they can choose to turn off all reminders or each reminder individually between certain hours so they are able to rest undisturbed.

Veterans with pressure ulcers typically take 10 – 12 medications, while Veterans with SCI may take 15 or more medications. Reminders for medications are not only helpful, but critical for some Veterans. “Set Reminders” includes the ability to build a highly customized list of medications from a template that includes the medication name (free form text for simplicity), frequency (how often to take it), rate (interval of when to take it), and starting and ending times for consumption.

Critical Task Automation

To further assist users with both cognitive and physical limitations, time-critical tasks were pre-programmed into “Get Help”. This gives users a single place in the App from which they can call 911, their medical team, the VA Crisis Line, the VA Caregiver Support Line, or a friend. Pernice recommends that links and automated actions be used with descriptive, true link text that immediately displays or performs the action the user expects (2014), so when a link is selected, the App asks users to confirm the action before placing a call or going outside the App and then performs the action.

Mariger recommends highlighting urgent or key information and using color for selective perception (as cited in Mariger, 2006). Likewise, Neilsen's 10 Usability Heuristics for User Interface Design recommend consistency and standards in usability. As a result, a red cross, an internationally recognized symbol for help, was placed in the tab bar to represent the page and ensure it was always available onscreen regardless of the operating system. "Any broken promise, large or small, chips away at trust and credibility. The words in a link label make a strong suggestion about the page that is being linked to." (Pernice, 2014). So, in addition to using a red cross to represent the functionality, the page was labeled "Get Help" so users would clearly understand the assistance it provided.

Figure 3 shows "Get Help" and what users experience by selecting three options on the page. "Start Veteran Chat" launches the device's web browser where the user can start a confidential online chat with a crisis counselor. "Get Directions" allows users to select "Find Me" where the GPS pinpoints their precise location or enter their zip code to get directions to both civilian hospitals and VA facilities near them, because in a true medical emergency, getting to "A" hospital could be more critical than getting to a VA hospital. VA hospitals are clearly distinguished from civilian hospitals with custom iconography. Like "Get Directions", "Help Near Home" lets users search for VA resources within a certain distance of a zip code. These resources often include Caregiver support counselors.

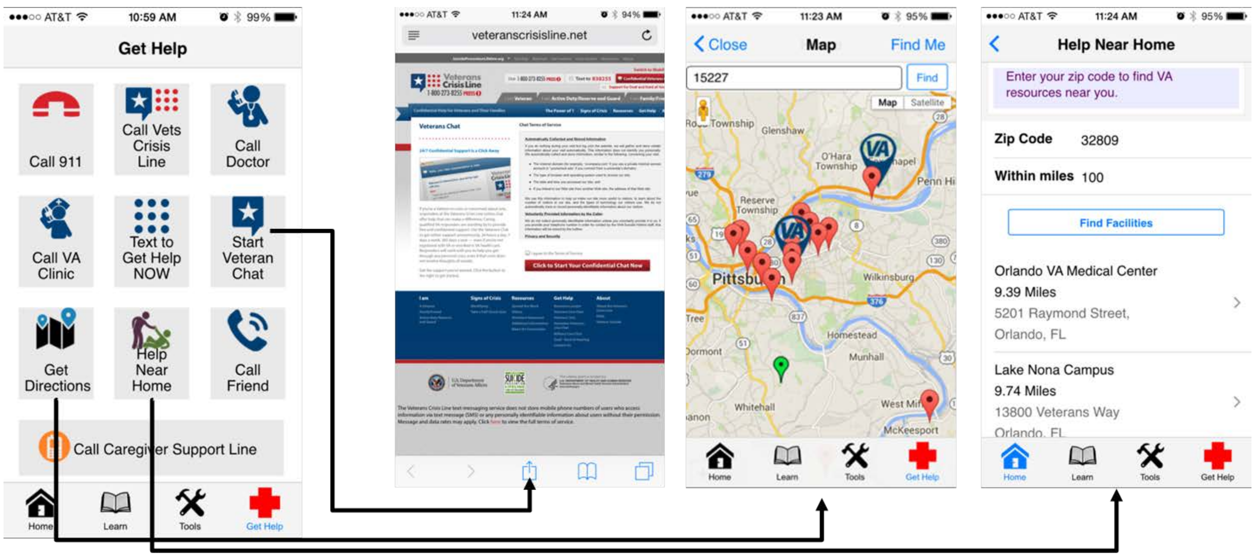

Figure 3: "Get Help" and Associated Resources

Iconography

"Appropriate graphics can be used to help reduce cognitive load and enhance understanding" (Mariger, 2014). She also recommends using "graphics and recognizable icons as navigation aids." Customized icons were created specifically for the App since universally recognized icons do not exist for most of the topics or tasks. Conforming to best practice, W3C requirements, and Pernice's recommendation (2014), labels were placed near each icon to clarify meaning and context; and each icon was large enough that users can safely target and touch them. According to Bedford, "icons must first and foremost communicate meaning in a graphical user interface" (2014). She says icons:

- Make good targets and are large enough to be easily touched in a finger-operated user interface (UI).
- Save space on already relatively small mobile device screens.
- Are recognizable and contextual.
- Add to the aesthetic appeal of the design.
- Categorize information at a glance (icons and styles are repeated when appropriate).

USABILITY TESTING

When the majority of design and development tasks were completed and a stable build of the App was available, the Human Factors Engineering team collected baseline summative metrics in addition to qualitative feedback on the

App. Key measures included task success, task failure, satisfaction (as measured by the System Usability Scale or SUS), and usability findings supported by both the metrics and qualitative interview portions.

Due to the limited dexterity (extremely limited hand movement in SCI patients being the most common) experienced by many of the participants, efficiency (time on task, mouse clicks, etc.) could not be accurately measured and was omitted from the final results. The summative metrics captured were used for a baseline comparison against the redesigned version of the App. Qualitative feedback was obtained to influence the decision on key mechanics and areas of the App, helping to determine what parts hold value. The study design was a hybrid of traditional summative testing and qualitative interviews commonly found in formative tests (VA, 2015c).

Participant Description

Nine participants representing the range of target users were recruited from the James A. Haley VA Hospital in Tampa, Florida for test sessions over the course of 3 days, February 23-25, 2015. All participants (men and women ages 30-90) were current inpatients, Caregivers, or Veterans at risk of a pressure ulcer at the VA facility. All participants volunteered after being recruited by a wound care nurse at the location. Participants accessed the App on a provided iPhone 5 and focused on key areas of the App. Participants were tasked with navigating through a series of common tasks in the App. Each session lasted approximately one hour. A usability specialist facilitated the sessions and sat next to the participant throughout the duration of testing (VA, 2015c).

Due to the physical limitations of the participants, the facilitator operated the data collection software, assisted with technical issues, and typed up descriptions dictated by participants. The facilitator prompted the participants prior to each task by providing instructions on the objective. Following each task, the facilitator verbally asked the participants questions and recorded their dictated responses before moving onto the next portion of testing. Additionally, a second usability specialist was in place to serve as a note taker. Participants were asked to complete nine common tasks which were considered basic examples of expected actions within the App (VA, 2015c). A summary of the specific recommendations based on task performance feedback is shown in Table 1.

Table 1. Key Usability Findings and Recommendations by Task

Task	Finding	Recommendation/Resolution
Select Questions from “Ask My Medical Team”	Topic list relied too much on text and it was difficult to read through the whole list to find a topic.	Add colorful, distinctive icons to represent each topic to make it easier to navigate through the topics. For users with cognitive limitations, graphics and recognizable icons are effective navigation aids (as cited in Mariger, 2006).
Locate the Veterans Crisis Line	67 percent of participants had issues locating the Veterans Crisis Line within the Help button when it was located in the top corner of the screen. Participants assumed it was not a button due to location. Participants assumed “Help” was for IT related help.	Move “Help” button from top right corner of App to the tab bar so it is in line with the other primary navigation functions. Rename button “Get Help” to distinguish from other IT related help functions.
“Set Reminder”	44 percent of participants had issues understanding they had to select to turn off the reminders before they slept to enable the feature. Participants didn’t notice the prompt prior to the time wheels.	The wheels to set a period of time to turn off reminders while sleeping shouldn’t be visible until users select the “Yes” button. Modify this function to only appear when “Yes” is selected.
Customize the “Home” Page	No participants could locate “Customize My Home Page” with ease when it was located inside settings.	Icons were created and placed on the home page so users would immediately know they could customize the home page. The main ability to do this was also relocated to “Tools”.

User Satisfaction Results

Participants completed the System Usability Scale (SUS) questionnaire at the end of their sessions. The SUS is a reliable and valid measure of system satisfaction. SUS scores range from 0 – 100. An SUS score above a 68 is considered above average and anything below 68 is below average. Broadly interpreted, scores under 68 represent systems with below average usability; scores over 68 are considered above average. The SUS questionnaire measures "perceived ease-of use," when taken directly after testing or exposure to its subject. It is the participant's "subjective view of the usability of the system." It is a measure of the sentiment toward the system, not the objective experience. As such, the SUS is not diagnostic and should not be taken out of context of the other usability metrics collected during testing (VA, 2015c).

Based on the SUS findings collected, subjective satisfaction with the system (based on performance of tasks in the session) was 78.8 (standard deviation, SD, = 8.8 excluding outliers). Scores ranged considerably from test to test and there were three outliers, with extremely low and high SUS scores. The SUS score including outliers was 71.9 (SD=21.3). This SUS score indicates an above average satisfaction ranking. The findings of the SUS were consistent with the qualitative questions investigating participants' overall impression of the App (VA, 2015c).

The SUS scores were examined against participant demographics to determine if self-assessed familiarity with tablets and smartphones correlated with the participants' level of satisfaction with the site (VA, 2015c).

Table 2. SUS Score and Technology/MHV familiarity comparison (VA, 2015c)

Participant	Gender	Age	SUS Score	What is your level of familiarity with using a tablet?	What is your level of familiarity with using a Smart Phone?
1	Male	30s	85.0	Intermediate	Intermediate
2	Male	70+	27.5	Basic	Basic
3	Male	50s	100	Advanced	Advanced
4	Female	40s	72.5	Intermediate	Intermediate
5	Male	50s	65.0	Advanced	Advanced
6	Male	60s	77.5	Advanced	Advanced
7	Male	60s	47.5	Basic	Intermediate
8	Female	60s	92.5	Intermediate	Advanced
9	Male	30s	80.0	Intermediate	Intermediate

Table 2 shows a noticeable correlation between participants who self-reported to be more experienced with technology and higher SUS scores. This may be due to more experienced users being more familiar with common App design principles, such as the multiple dots used to signify additional pictures being available in iOS. Aside from technology familiarity, the App in general was well received with many participants stating that the type of information in the App would be extremely helpful. In particular, a few participants mentioned that the plethora of information in the Learn section would be helpful even outside of the context of pressure ulcers. The high SUS scores may also be attributed to the fact that the App is dedicated to a health condition in which the participants are invested (VA, 2015c).

LESSONS LEARNED (LL)

While many lessons were learned throughout the development of the App, lessons identified below related directly to usability design considerations for users with physical and cognitive limitations.

LL #1: Follow good usability principles.

Following good usability principles for the design and development of mobile applications is the first step in ensuring the design will work for individuals with physical and cognitive limitations. Use information and presentation formats that are very familiar to people such as FAQs to simplify navigation and provide an intuitive interface. Maintain the presentation format throughout the App. Keep content, navigation, and task language at the lowest Flesch-Kincaid level possible to meet the needs of all users regardless of their physical or cognitive condition. This helps all users, not only those with limitations. Adding additional considerations for shorter text, more imagery, larger selection areas, and familiar formats would make any mobile application design better for a wider audience. Most general usability recommendations cited in this paper applied directly to the recommendations made for users with physical and cognitive limitations.

LL #2: Engage client usability testing groups early.

Create and maintain wireframes by version from the start of the project. Engage the client's usability team in the wireframe reviews early to ensure best practices are adhered to and potential issues are identified before user testing. This will reduce rework and produce better user testing results thereby saving time and effort. In the case of this App, the recommendations from the usability team and actual users dramatically improved the quality of the App.

LL #3: Do not underestimate the significance of imagery.

Create unique, highly recognizable icons to reduce wording and facilitate navigation. This will help users with cognitive limitations associate tasks and content easier. Create high resolution (minimum of 300dpi) images so the App can adapt to various device types and screen sizes.

REUSE AND PORTABILITY

While designing the App for those with physical and cognitive limitations, significant consideration was given to ensuring the resulting information architecture and design templates could be reusable by other VA audiences for new subject matter and portable to various platforms and devices. The App was developed in HTML 5 as a hybrid App to enable deployment to iOS, Android, and Windows phones and tablets from a single code-base. It is packaged as a native App using Apache Cordova and Kendo UI as the cross-platform user interface development tools. This approach enables the App to access each device's native capabilities such as the camera used in "My Journal" and the GPS used for "Get Directions" and "Help Near Home."

The App's information architecture focuses on *how information is accessed* rather than *what information users can access*. As a result, it is content-neutral and can be reused to support chronic medical conditions such as amputation, COPD, diabetes, and heart disease with minimal modification to the code or the cascading style sheet (CSS). Table 3 shows examples of how the App's components could be adapted to suit different audiences and subject matter.

Table 3: Reusable Components of VAPUR Information Architecture for Other Chronic Conditions

VAPUR Section	**Reuse by Chronic Condition**			
	Amputation	**COPD**	**Diabetes**	**Heart Disease**
Journal Entry	Yes[2]	Yes[2]	Yes[2]	Yes[2]
Set Reminders	Yes	Yes	Yes	Yes
Find Symptoms/Causes	Yes[2]	Yes[2]	Yes[2]	Yes[2]
Ask My Medical Team	Yes[2]	Yes[2]	Yes[2]	Yes[2]
Learn > Pressure Ulcers	Yes	No	Yes	No
Learn > Nutrition, Exercise, Vital Signs, Medicines, Pain (Management), Home Safety, Caregiver Tips	Yes	Yes	Yes	Yes
Tools > Video Tutorials	Yes[2]	Yes[2]	Yes[2]	Yes[2]
Tools > Appointments	Yes	Yes	Yes	Yes
Tools > Settings	Yes	Yes	Yes	Yes
Tools > About This App	Yes[2]	Yes[2]	Yes[2]	Yes[2]
Get Help	Yes[1]	Yes[1]	Yes[1]	Yes[1]

[1] Requires no modification for VA, slight modification for outside the VA.
[2] Requires some modification to be reused

With the exception of the application programming interface (API) to the VA, the App and its information architecture could also be reused outside the VA. However, the API could be adapted to support any medical records database because the format of the transmitted data was standardized and mapped to the LOINC and SNOMED – CT standards that are not VA-specific.

CONCLUSION

The human-computer interface considerations made in VAPUR demonstrate how making simple usability considerations in the design can result in an App that can meet the needs of a broad range of users, including those with both physical and cognitive limitations. As the U.S. population, particularly Baby Boomers, ages the audience requiring Apps that support those with physical and cognitive limitations resulting from illness, injury, and age will continue to grow. Accounting for the needs of this growing group will improve their quality of life and allow medical teams to provide responsive, continual care and support.

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